DRAFT

Water and Sediment Quality Criteria Report for Esfenvalerate

Phase III: Application of the pesticide water and sediment quality criteria methodologies

Prepared for the Central Valley Regional Water Quality Control Board

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Disclaimer

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List of acronyms and abbreviations

ACR	Acute-to-Chronic Ratio
AF	Assessment Factor
ASTM	American Society for Testing and Materials
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BMF	Biomagnification Factor
BSQC	Bioavailable Sediment Quality Criteria
CAS	Chemical Abstract Service
CDFG/CDFW	California Department of Fish and Wildlife
CDPR	California Department of Pesticide Regulation
CDWR	California Department of Water Resources
CVRWQCB	Central Valley Regional Water Quality Control Board
DOC	Dissolved Organic Carbon
DOM	Dissolved Organic Matter
EC_x	Concentration that affects x% of exposed organisms
FDA	Food and Drug Administration
FT	Flow-through test
GMAV	Genus Mean Acute Value
IA	Independent Action
IC_x	Inhibition concentration; concentration causing *x*% inhibition
ICE	Interspecies Correlation Estimation
IUPAC	International Union of Pure and Applied Chemistry
K	Interaction Coefficient
K_H	Henry's law constant
K_{ow}	Octanol-Water partition coefficient
K_{oc}	Organic Carbon sorption partition coefficient
K_p or K_d	Solid-Water partition coefficient
LC_x	Concentration lethal to *x*% of exposed organisms
LD_x	Dose lethal to *x*% of exposed organisms
LL	Less relevant, Less reliable study
LOEC	Lowest-Observed Effect Concentration
LOEL	Lowest-Observed Effect Level
LR	Less relevant, Reliable study
MATC	Maximum Acceptable Toxicant Concentration
N	Not relevant or Not reliable study
n/a	Not applicable
NEC	No-effect concentration
NOAEL	No-Observed Adverse Effect Level
NOEC	No-Observed Effect Concentration
NR	Not reported
OC	Organic Carbon
PBO	Piperonyl butoxide
pK_a	Acid dissociation constant
RL	Relevant, Less reliable study

RR	Relevant and Reliable study
S	Static test
SMAV	Species Mean Acute Value
SMCV	Species Mean Chronic Value
SPME	Solid-phase Microextraction
SR	Static renewal test
SSD	Species Sensitivity Distribution
TES	Threatened and Endangered Species
TIE	Toxicity Identification Evaluation
UCDM	University of California Davis water quality criteria derivation methodology
UCDSM	University of California Davis sediment quality criteria derivation methodology
US	United States
USEPA	United States Environmental Protection Agency

1 Introduction

Two new methodologies for deriving freshwater water quality criteria (TenBrook et al. 2009) and sediment quality criteria (Fojut et al. 2014) for the protection of aquatic life have been developed by the University of California, Davis. The need for these new methodologies was identified by the California Central Valley Regional Water Quality Control Board (CVRWQCB 2006, CRWQCB-CVR 2011) and findings from reviews of existing methodologies (TenBrook & Tjeerdema 2006, TenBrook et al. 2009, Fojut et al. 2011, 2013). These new methodologies are currently being used to derive aquatic life criteria for several pesticides of particular concern in the Sacramento River and San Joaquin River watersheds. The water quality criteria methodology report (TenBrook et al. 2009) and the sediment quality criteria report (Fojut et al. 2014) each contain an introduction; the rationale of the selection of specific methods; detailed procedures for criteria derivation; and a criteria report for a specific pesticide. This criteria report for esfenvalerate describes, section by section, the procedures used to derive both the water quality criteria and sediment quality criteria according to the UC-Davis Method (UCDM) and UC-Davis Sediment Method (UCDSM), respectively. Also included are references to specific sections of the methodology procedures detailed in these reports so that the reader can refer to the appropriate report for further details (TenBrook et al. 2009, Fojut et al. 2014).

2 Basic information

Chemical: Esfenvalerate (Fig. 1)

CAS: (S)-cyano(3-phenoxyphenyl)methyl (αS)-4-chloro-α-(1-methylethyl)benzeneacetate

IUPAC: (αS)-α-cyano-3-phenoxybenzyl (2S)-2-(4-chlorophenyl)-3-methylbutyrate

Chemical Formula: $C_{25}H_{22}ClNO_3$

CAS Number: 66230-04-4

CA DPR Chem Code: 2321

Trade names: DBX-GB800; Asana®; Asana XL®; S-1844; S-5602 Alpha; WL 43775; SD 43775; Supercidin®; Halmark®; Sumidan® (Adelsbach & Tjeerdema 2003, Laskowski 2002).

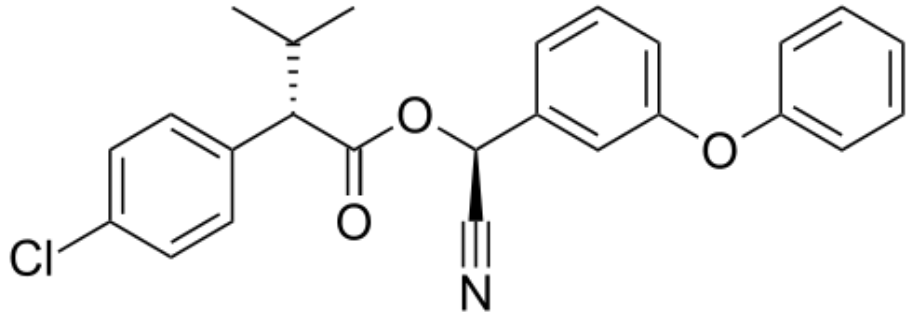

Figure 1 Structure of esfenvalerate, a type II pyrethroid.

3 Physicochemical data

Molecular Weight
419.9 Laskowski 2002

Density
1.21 g/mL (20°C) Kelley 2004

Water Solubility
0.01 mg/L at 25°C Laskowski 2002
0.002 mg/L at 25°C Kelley 2004
Geomean: 0.004 mg/L

Melting Point
59-60°C (Kelley 2004)

Vapor Pressure
1.44E-07 mm Hg (20°C, Laskowski 2002)
1.50E-09 mm Hg (25°C, Laskowski 2002)
0.067 mPa (25°C, Kelley 2004)
2E-04 mPa (25°C, Adelsbach & Tjeerdema 2003)
Geomean: 2.68E-06 Pa

Organic Carbon Sorption Partition Coefficients (K_{oc})
5,300 IUPAC 2013
215,000 Kelley 2004
630,957 European Commission 2005
375,000 Hamilton 2004
140,000 Hamilton 2004
85,700 Hamilton 2004
141,700 Hamilton 2004
596,200 Hamilton 2004
171,700 Hamilton 2004
5,248 PubChem 2011
251,700 DuPont 2002

Geomean: 161,000

Henry's constant (K_H)

1.4 x 10^{-7} atm m^3 mol^{-1} (0.0141855 Pa m^3 mol^{-1})	Laskowski 2002
0.042 Pa m^3 mol^{-1}	Adelsbach & Tjeerdema 2003

Geomean: 0.024 Pa m^3 mol^{-1}

Log K_{ow}

6.22	Laskowski 2002
5.01	Laskowski 2002
6.2	Adelsbach & Tjeerdema 2003
6.2	Kelley 2004

Geomean: 5.9

Environmental Fate

Table 1 Bioconcentration factors (BCF) for esfenvalerate; FT: flow-through; NR: not reported.

Species	BCF (L/kg)	Exposure	Reference
Cyprinus carpio	2,390	FT	Laskowski 2002
Cyprinus carpio	Test 1: 3,710 Test 2: 3,870	FT	Ohshima & Mikami 1991
Lepomis macrochirus	3,650	NR	Kelley 2004

Table 2 Esfenvalerate hydrolysis, photolysis, and biodegradation. NR: not reported.

	Half- life (d)	Water	Temp (°C)	pH	Reference
Hydrolysis	0 (stable to hydrolysis)	Sterile buffer	25	5	Laskowski 2002
	0 (stable to hydrolysis)	Sterile buffer	25	7	Laskowski 2002
	0 (stable to hydrolysis)	Sterile buffer	25	9	Laskowski 2002
Aqueous Photolysis	18.1	Sterile buffer	NR	NR	Laskowski 2002
Aqueous Biodegradation (aerobic)	17.0 (geomean of 2 values)	NR	10-19	NR	Kelley 2004

4 Human and wildlife dietary values

There are no FDA action levels for esfenvalerate (USFDA 2000), but food tolerances are provided for human consumption of various produce and meat commodities, ranging from 0.02 to 15 mg/kg (USEPA 2009). There are currently no food tolerances for the human consumption of other meat or fish products.

Toxicity data for the mallard duck have been used in previous WQC and BSQC reports to assess if the derived criteria would be protective of wildlife (Fojut et al. 2012, Fojut et al. 2014). The mallard duck toxicity values are also relevant for comparison to the derived WQC and BSQC for esfenvalerate; as such, the toxicity values for the mallard duck are summarized here.

An eight-day dietary LC_{50} of 5,274 mg/kg feed (Kelley 2004) and an oral LD_{50} of 2250 mg/kg have been reported for mallard ducks (EXTOXNET 1996). An 8-day dietary NOEC for mallard ducks of 562 mg/kg was reported for esfenvalerate, as well as a dietary LC_{50} of 4,894 mg/kg (Driscoll 1990). No other data was found to assess the toxicity of esfenvalerate on mallard ducks.

5 Ecotoxicity data

Aquatic and sediment toxicity effects studies were identified in the peer-reviewed open literature and from unpublished studies submitted to the USEPA and CDPR for esfenvalerate.

Each study was reviewed according to the UCDM or UCDSM paradigms to determine the usefulness of these studies for water or sediment quality criteria derivation, respectively. Studies were divided into three categories to be rated: (1) single-species effects, (2) ecosystem-level studies, and (3) terrestrial wildlife studies.

The UCDM and UCDSM provide detailed numeric rating schemes for single-species effects studies that assigns (1) a relevance score and (2) a reliability score, which are summarized in TenBrook et al. (2009) and Fojut et al. (2014). The possible relevance scores were relevant (R), less relevant (L), or not relevant (N). The studies rated N were deemed irrelevant for criteria derivation and only the relevant (R) and less relevant (L) studies were evaluated for reliability. For all studies, study details and scoring were summarized in data summary sheets (Appendix A – Aqueous Toxicity Data Summaries and Appendix B – Sediment Toxicity Data Summaries). The reliability evaluation assigned possible scores of reliable (R), less reliable (L), or not reliable (N) so that each single-species study is described by a two-letter code, corresponding to the relevance and reliability ratings. The only studies used directly in criteria calculations were those rated as relevant and reliable (RR), which are summarized in Table 3 and Table 5 for aqueous studies and Table 8 for sediment studies. Studies that were rated as relevant and less reliable (RL), less relevant and reliable (LR), or less relevant and less reliable (LL) were used to evaluate the derived criteria against data for any particularly sensitive, threatened, or endangered species found in these data sets. Studies that were rated N for either relevance or reliability were not considered in any aspect of criteria derivation.

Multispecies studies conducted in mesocosms, microcosms, and other field and laboratory ecosystems were rated for reliability. The results of the studies that were rated reliable (R) or less reliable (L) were compared to the derived criteria to ensure that they are protective of ecosystems. Studies of the effects of esfenvalerate on mallard ducks were rated for reliability using the terrestrial wildlife evaluation. Mallard studies rated as reliable (R) or less reliable (L) were used to consider bioaccumulation of pyrethroids.

6 Data Prioritization

Multiple toxicity values for esfenvalerate for the same species were reduced to one species mean toxicity value according to the data prioritization procedures described in the UCDM or UCDSM methodology reports. The aqueous toxicity data that were reduced and the reasons for their exclusion are shown in Table 4 and Table 6. Reasons for reduction of data include: longer duration tests were available, more sensitive endpoints were available, and tests at standard conditions were available. The final acute data set for water quality criteria calculation contains eight SMAVs (Table 3) and the final chronic data set contains three SMCVs (Table 5).

Sediment toxicity data were reduced and the reasons for their exclusion are shown in Table 9. Reasons for reduction of data include: more sensitive endpoints were available. The final acute data set for sediment quality criteria calculation contains two SMAVs (Table 8). There were no chronic data available for chronic criterion calculation.

7 Acute Criteria Calculations

7.1 Acute WQC

At least five acceptable acute toxicity values were available and fulfilled the five taxa requirements of the species sensitivity distribution (SSD) procedure (section 3-3.1, TenBrook et al. 2009). The five taxa requirements are a warm water fish, a fish from the family Salmonidae, a planktonic crustacean, a benthic crustacean, and an insect. Acute values were plotted in a histogram (Figure 2), and do not appear to be bimodal.

The log-logistic SSD procedure (section 3-3.2.2, TenBrook et al. 2009) was used for the acute criterion calculation because there were not more than eight acceptable acute toxicity values available in the esfenvalerate data set (Table 3). The log-logistic SSD procedure was used to derive 5th percentile values (median and lower 95% confidence limit), as well as 1st percentile values (median and lower 95% confidence limit). The median 5th percentile value is recommended for use in criteria derivation by the methodology because it is the most robust of the distributional estimates (section 3-3.2, TenBrook et al. 2009). Comparing the median estimate to the lower 95% confidence limit of the 5th percentile values, it can be seen that the first significant figures of the two values are different (0.044856 vs. 0.008864 μg/L). Because there is uncertainty in the first significant digit, the final criterion will be reported with one significant digit (section 3-3.2.6, TenBrook et al. 2009).

The ETX 1.3 Software program (Aldenberg 1993) was used to fit a log-logistic distribution to the data set, which is plotted with the acute values in Figure 3. This distribution provided a satisfactory fit according to the fit test described in section 3-3.2.4 of TenBrook et al. (2009). No significant lack of fit was found (χ^2_{2n} = 0.2017) using the fit test based on cross validation and Fisher's combined test (Appendix C – Acute WQC Fit Test), indicating that the data set is valid for criteria derivation.

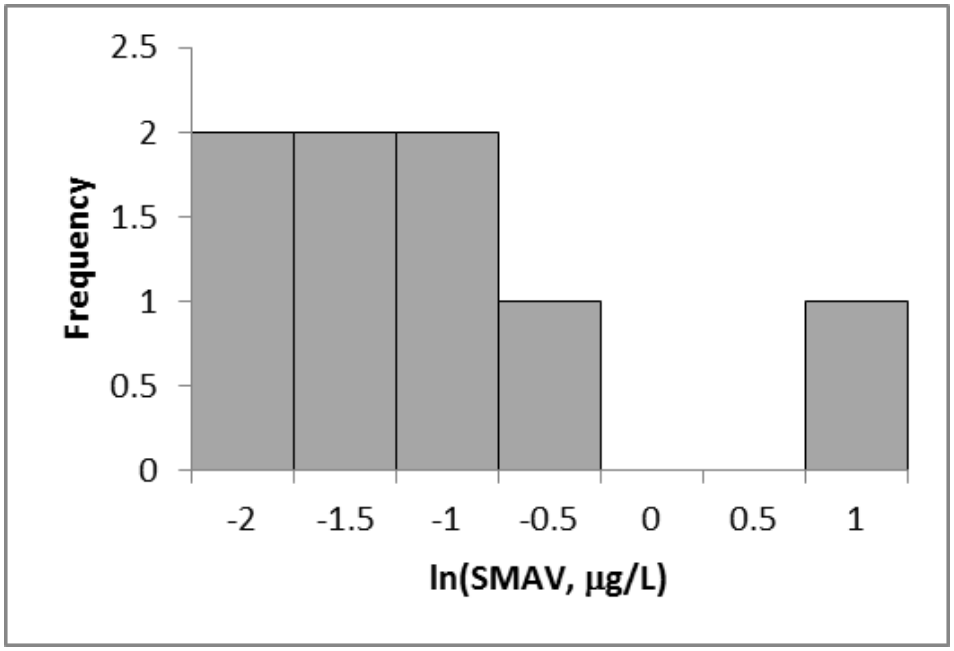

Figure 2 Histogram of acceptable acute aqueous esfenvalerate data.

Log-logistic distribution

HC5 Fitting Parameter Estimates: α = -0.5784, β (median) = 0.2614, β (lower 95% CI) = 0.5006.

5th percentile, 50% confidence limit: 0.044856 µg/L
5th percentile, 95% confidence limit: 0.008864 µg/L
1st percentile, 50% confidence limit: 0.016606 µg/L
1st percentile, 95% confidence limit: 0.001322 µg/L

Recommended acute value = 0.044856 µg/L (median 5th percentile value)

Acute WQC = Recommended acute value ÷ 2
= 0.044856 µg/L ÷ 2
= 0.022428 µg/L

Acute WQC = 0.02 µg/L
= 20 ng/L

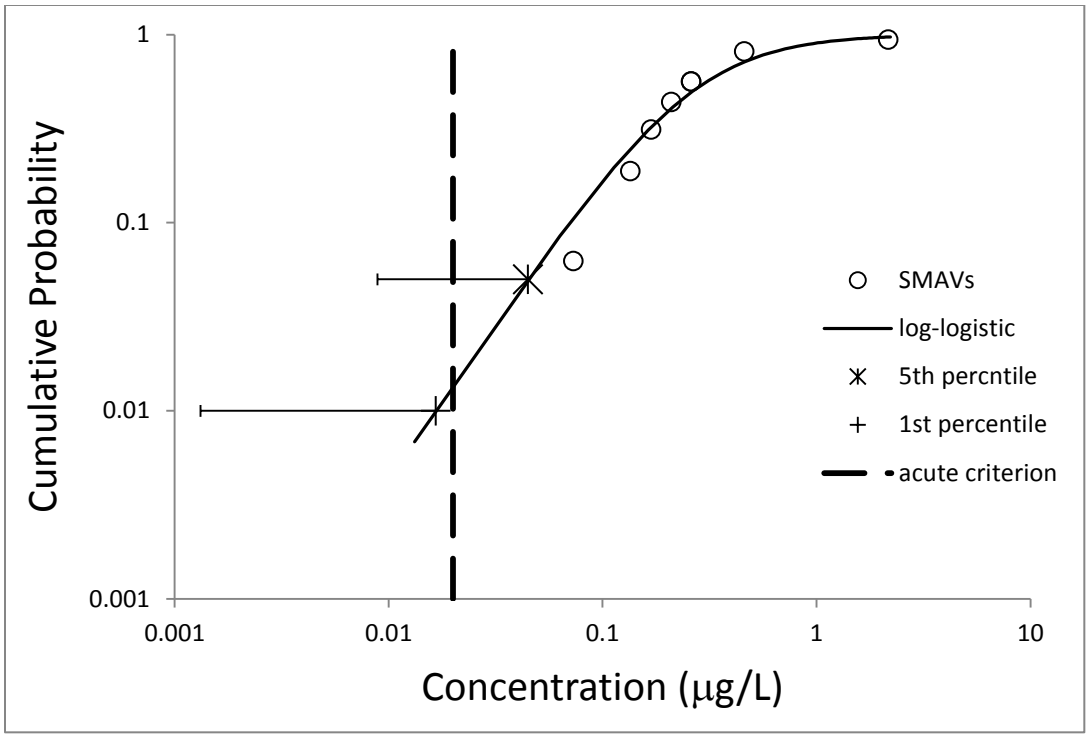

Figure 3 The fit of the log-logistic distribution to the acute aqueous data set.
The median 5th percentile acute value and the median 1st percentile acute value are each displayed with their respective lower 95% confidence limit. The acute water quality criterion calculated with the median 5th percentile value is displayed as a vertical line.

7.2 Interim acute BSQC

Only two of the five taxa required to construct a species sensitivity distribution were available for bifenthrin, thus an assessment factor was used to calculate the acute BSQC. The epibenthic crustacean requirement is represented by the amphipod *H. azteca*, and the benthic insect category is represented by *C. dilutus*. The three missing taxa are an infaunal invertebrate, a mollusk/amphibian/other unrepresented phylum, and a benthic invertebrate from an unrepresented family.

The acute criterion is calculated by dividing the lowest SMAV in the acceptable (RR) data set by an assessment factor. The AF is chosen based on the number of taxa in the data set as described in section 3.5 of the UCDSM. The AF for a data set with 2 taxa is 12.

The lowest SMAV for esfenvalerate was an OC-normal sediment concentration of 0.29 µg/g OC, which is a 10-d *H. azteca* LC_{50} (Table 3). The lowest SMAV is divided by the appropriate AF to estimate the 5th percentile of the SSD. This 5th percentile is the recommended acute value, which is divided by two to derive the acute BSQC.

Acute value = lowest SMAV ÷ assessment factor
= 0.29 μg/g OC ÷ 12
= 0.024 μg/g OC

Acute BSQC = acute value ÷ 2
= 0.024 μg/g OC ÷ 2
= 0.012 μg/g OC

Acute BSQC = 0.012 μg/g OC
= 12 ng/g OC

8 Chronic Criteria Calculations

8.1 Chronic WQC

Chronic toxicity values from fewer than five different families were available, thus the acute-to-chronic ratio (ACR) method was used to calculate the chronic criterion (section 3-4.2, TenBrook et al. 2009). Three chronic toxicity values are in the acceptable (rated RR) data set (Table 5) satisfying three of the five taxa requirements (section 3-3.1, TenBrook et al. 2009): Insect (*Baetis* spp.), warm water fish (*Lepomis macrochirus)* and planktonic crustacean (*Daphnia magna).*

One of the chronic toxicity values could be paired with an appropriate corresponding acute toxicity value in order to calculate an ACR, satisfying the invertebrate family requirement of the methodology (section 3-4.2.1, TenBrook et al. 2009). The acute and chronic studies with *Daphnia magna* were both performed by Hutton (1987a, 1987b) at the same facilities using the same dilution water, which satisfies the recommendations of the UCDM (section 3-4.2.1, TenBrook et al. 2009). The other chronic values did not have appropriate acute toxicity values to calculate ACRs. The daphnid ACR was calculated by dividing the acute LC_{50} value (0.90 μg/L) by the chronic MATC value (0.064 μg/L), and resulted in an ACR of 14.

The final multi-species ACR was obtained by calculating the geometric mean of the daphnid ACR with two default ACR values to account for the lack of other empirically derived ACRs (section 3-4.4.4, TenBrook et al. 2009). The default ACR of the UCDM (TenBrook et al. 2009) was updated by Fojut et al. (2014) to include additional pesticide data sets, specifically for the pyrethroids cyfluthrin and λ-cyhalothrin. The updated default ACR calculated by Fojut et al. (2014) is 11.4. The final multi-species ACR value calculated as the geometric mean of three ACRs (14, 11.4, and 11.4) is 12.2. The chronic criterion was calculated using the recommended

acute value, which was the acute median 5th percentile value, and the final multi-species ACR value as follows:

Chronic WQC = recommended acute value ÷ ACR

= 0.044856 μg/L ÷ 12.2

= 0.0036767 μg/L

Chronic WQC = 0.003 μg/L

= 3 ng/L

8.2 Interim chronic BSQC

Due to the dearth of chronic data in both the acceptable and supplemental data sets for esfenvalerate, no SMCVs could be calculated and thus the ACR procedure is used to calculate the chronic criterion for this compound (section 3.6.3 of the UCDSM). The lack of chronic sediment toxicity data for esfenvalerate also prevents the calculation of an ACR by pairing appropriate acute and chronic spiked sediment toxicity studies. Because an experimental ACR cannot be calculated for esfenvalerate, the chronic criterion is calculated with the default ACR of 11.4 (UCDSM) and the acute value as follows:

Chronic BSQC = acute value ÷ ACR
= 0.024 μg/g OC ÷ 11.4
= 0.0021 μg/g OC

Chronic BSQC = 0.0021 μg/g OC
= 2.1 ng/g OC

9 Water Quality Effects

9.1 Bioavailability

Although esfenvalerate and other pyrethroids are not very soluble in water, aquatic organisms are very sensitive to pyrethroids and toxicity does occur. Pyrethroids have been found as the cause of toxicity in surface waters in the California Central Valley (Phillips et al. 2007, Weston et al. 2009, Weston and Lydy 2010). This toxicity is believed to occur primarily from the

fraction of the compound that is dissolved in the water, not from the compound that is associated with the particulate phase.

Several studies suggest that the binding of esfenvalerate and other pyrethroids to suspended solids and dissolved organic matter (DOM) will make the bound fraction unavailable and thus nontoxic to aquatic organisms. Yang et al. (2006a) examined the acute toxicity of esfenvalerate by *Ceriodaphnia dubia* with various levels of suspended sediment. These researchers found that low levels of suspended sediment (50-200 mg/L) reduced esfenvalerate toxicity to *C. dubia*. They also measured the phase distribution between water and suspended sediment and found that the K_d values did not correlate with organic carbon content of the suspended sediment. This indicates that the quantity of OC did not directly correlate with sorption, and that the quality, or characteristics, of the OC also affected uptake.

There are many studies on pyrethroids, not necessarily including esfenvalerate, that also demonstrate decreased toxicity of pyrethroids in the presence of sediment, DOC, and other natural sorbents (Day 1991; Smith and Lizotte 2007; Xu et al. 2007; Yang et al. 2006b, 2007). These studies suggest that the freely dissolved concentration will be the most accurate predictor of toxicity and that bound esfenvalerate was unavailable to the studied organisms.

As a counterpoint, equilibrium partitioning would suggest that as organisms take up esfenvalerate, more esfenvalerate will desorb from particles, so the fraction absorbed to solids is likely not completely unavailable. According to the equilibrium partitioning model, esfenvalerate would continue to desorb from particles as organisms took it up, but the dissolved concentration would be constant if the system was at steady-state. This means that the duration of exposure could be increased, but not likely the magnitude. Benthic organisms, such as *Hyalella azteca*, may be at greater risk because of their exposure to interstitial water and close proximity to sediments.

Additionally, the role of dietary exposure on bioavailability of pyrethroids has not been extensively considered. Organisms living in contaminated waters may also be ingesting food with sorbed hydrophobic compounds that can be desorbed by digestive juices (Mayer et al. 2001). The effects of dietary exposure may also be species-specific, depending on typical food sources; some species may have greater interaction with particles, increasing their exposure. Palmquist et al. (2008a) examined the effects due to dietary exposure of esfenvalerate on three aqueous insects with different feeding functions: a grazing scraper (*Cinygmula reticulata* McDunnough), an omnivore filter feeder (*Brachycentrus americanus* Banks), and a predator (*Hesperoperla pacifica* Banks). The researchers observed adverse effects in *C. reticulata* and *B. americanus* after feeding on esfenvalerate-laced food sources and that none of the three insects avoided the contaminated food. The effects included reduced growth and egg production of *C. reticulata* and abandonment and mortality in *B. americanus*. These limited studies indicate that ingestion may be an important exposure route, but it is not currently possible to incorporate this exposure route into criteria compliance assessment.

Section 3-5.1 of the methodology (TenBrook et al. 2009) suggests that if studies indicate that fewer than three phases of the pesticide (sorbed to solids, sorbed to dissolved solids, or freely dissolved in the water) are bioavailable that compliance may be based on the concentration in the bioavailable phase(s). The studies above suggest that the freely dissolved fraction of esfenvalerate is the primary bioavailable phase, and that this concentration is the best indicator of toxicity, thus, it is recommended that the freely dissolved fraction of esfenvalerate be directly measured or calculated based on site-specific information for compliance assessment. Whole water concentrations are also valid for criteria compliance assessment, and may be used at the discretion of environmental managers, although the bioavailable fraction may be overestimated with this method.

The most direct way to determine compliance would be to measure the esfenvalerate concentration in the dissolved phase to determine the total bioavailable concentration. SPME has shown to be the best predictor of pyrethroid toxicity in several studies (Bondarenko et al. 2007, Bondarenko & Gan 2009, Hunter et al. 2008, Xu et al. 2007, Yang et al. 2006a, 2006b, 2007). Bondarenko & Gan (2009) report a method detection limit of 1.2 ng/L for esfenvalerate, although method detection limits vary between laboratories. Filtration of sediments is another option. Glass fiber filters with a nominal pore size of 0.7 μm or 0.45 μm are often used to remove the suspended sediments or both suspended sediments and dissolved organic matter, but the filters can interfere with the detection of hydrophobic contaminants. Gomez-Gutierrez et al. (2007) found that adsorption to filters was positively correlated with the log K_{ow} and solubility values of the compounds, and that on average 58% of the one pyrethroid tested (a 50 ng/L solution of permethrin) was lost on the filter. This loss may be critical for determining compliance at environmental concentrations.

Alternately, the following equation can be used to translate total esfenvalerate concentrations measured in whole water to the associated dissolved esfenvalerate concentrations:

$$C_{dissolved} = \frac{C_{total}}{1 + ((K_{OC} \cdot [SS]) / foc) + (K_{DOC} \cdot [DOC])} \quad (1)$$

where:
$C_{dissolved}$ = concentration of chemical in dissolved phase (μg/L);
C_{total} = total concentration of chemical in water (μg/L);
K_{OC} = organic carbon-water partition coefficient (L/kg);
[SS] = concentration of suspended solids in water (kg/L);
f_{oc} = fraction of organic carbon in suspended sediment in water;
[DOC] = concentration of dissolved organic carbon in water (kg/L);
K_{DOC} = organic carbon-water partition coefficient (L/kg) for DOC.

To determine compliance by this calculation, site-specific data are necessary, including: K_{OC}, K_{DOC}, the concentration of suspended solids, the concentration of DOC, and the fraction of organic carbon in the suspended solids. If all of these site-specific data, including the partition coefficients, are not available, then this equation should not be used for compliance determination. Site-specific data are required because the sorption of esfenvalerate to suspended solids and dissolved organic matter depends on the physical and chemical properties of the suspended solids resulting in a range of K_{OC} and K_{DOC} values, as discussed earlier in this section.

The freely dissolved esfenvalerate concentration is recommended for determination of WQC compliance because the literature suggests that the freely dissolved concentrations are the most accurate predictor of toxicity. Environmental managers may choose an appropriate method for determination of the concentration of freely dissolved esfenvalerate, or they may also choose to base compliance on whole water concentrations.

For the interim BSQC, bioavailability is directly incorporated into the UCDSM by using bioavailability-based toxicity values to derive criteria. The BSQC are expressed OC-normalized sediment concentrations, and may be converted to freely dissolved interstitial water concentrations if desired to compare to interstitial water concentrations. If site-specific partition coefficients are available they can be used to convert between phases. If a site-specific partition coefficient is not available, then the geometric mean of acceptable partition coefficients can be used. To compare the OC-normalized sediment BSQC to relevant aqueous concentrations, the BSQC were converted to interstitial water concentrations using the K_{OC} of 161,000, which is the geometric mean of 11 values (section 3). The resulting acute and chronic interstitial concentrations of the interim BSQC are 0.075 ng/L and 0.013 ng/L, respectively. These concentrations will be compared to aqueous data in other sections.

9.2 Mixtures

Esfenvalerate often occurs in the environment with other pyrethroid pesticides (Trimble et al. 2009, Werner & Moran 2008), and the presence of chemicals in surface waters is ubiquitous. All pyrethroids have the same toxicological mode of action, and several studies have demonstrated that the toxicity of pyrethroid mixtures is additive and is well-predicted by the concentration addition model (Barata et al. 2006, Brander et al. 2009, Trimble et al. 2009). Overall, the concentration addition model should be used by following either the toxic unit or relative potency factor approach to determine criteria compliance when multiple pyrethroids are present. Definitions of additivity, synergism, antagonism, and non-additivity are available in the literature (Lydy and Austin 2004) and more detailed descriptions of mixture models can be found in the UCDM (section 3-5.2, TenBrook et al. 2009).

Barata et al. (2006) observed slight antagonism for *D. magna* survival for λ-cyhalothrin – deltamethrin mixtures, but the deviation from additivity was attributed to a few unexpected extreme values for joint survival effects, as most observed effects were within a factor of two of

the effects predicted by the concentration addition model. Brander et al. (2009) tested mixture toxicity of cyfluthrin and permethrin, and found slight antagonism for the binary mixture, but additivity was demonstrated when piperonyl butoxide (PBO) was added. Brander et al. (2009) offered several explanations for the observed antagonism between the two pyrethroids. Permethrin is a type I pyrethroid, and cyfluthrin is a type II pyrethroid, and type II pyrethroids may be able to outcompete type I pyrethroids for binding sites, which is known as competitive agonism; or binding sites may be saturated, so that complete additivity is not observed. They also note that cyfluthrin is metabolized more slowly than permethrin, so cyfluthrin can bind longer. PBO may remove this effect because the rate of metabolism of both pyrethroids is reduced in its presence. To examine if pyrethroid mixture toxicity is additive with a more comprehensive study design, Trimble et al. (2009) performed sediment toxicity tests with *H. azteca* in three binary combinations: type I-type I (permethrin-bifenthrin), type II-type II (cypermethrin-λ-cyhalothrin), and type I-type II (bifenthrin-cypermethrin). The toxicity of these combinations were predicted with the concentration addition model, with model deviations within a factor of two, indicating that in general, pyrethroid mixture toxicity is additive.

Piperonyl butoxide (PBO) is commonly added to pyrethroid insecticide treatments because it is known to increase the toxic effects of pyrethroids (Weston et al. 2006). Mixtures of esfenvalerate and PBO have been demonstrated to have synergistic toxicity to various terrestrial pests and nontarget insects (Cochran 1994, Hamilton and Lashomb 1997). Only a few studies have examined the effects of combinations of PBO a pyrethroids on aquatic organisms, and none of these have tested esfenvalerate. Brausch and Smith (2009) tested toxicity of cyfluthrin alone and a combination of cyfluthrin and PBO with *Daphnia magna* and found that the LC_{50} of cyfluthrin alone (0.62 μg/L) was higher than that for cyfluthrin tested with a constant sublethal concentration of PBO (0.46 μg/L). Brander et al. (2009) observed *Hyalella azteca* LC_{50} values decreased by a factor of 2 or 3.5 when a nonlethal concentration of PBO was mixed with cyfluthrin or permethrin, respectively.

Joint toxicity of esfenvalerate and organophosphate pesticides has been studied with several species. The joint toxicity of esfenvalerate and chlorpyrifos to fathead minnows (*Pimephales promelas*) and midge larvae (*Chironomus dilutus*) was investigated by Belden and Lydy (2006). The results were compared to the concentration addition and independent action model predictions. Greater than predicted toxicity was observed for fathead minnows compared to both models, but observed toxicity was within a factor of two of the predicted toxicity. For midge larvae, observed toxicity was similar to what was predicted with the concentration addition model, but the independent action model underpredicted toxicity. The lack of agreement between observed and predicted toxicity indicates that there may be a toxicokinetic interaction occurring between these two pesticides. Joint toxicity of esfenvalerate and diazinon to fathead minnows also appears to result in greater than additive toxicity (Denton et al. 2003)

Synergy between azole fungicides and pyrethroids has been reported (Bjergager et al. 2011, 2012). These studies investigated synergy between prochloraz and esfenvalerate in acute and subchronic exposures of *Daphnia magna* and other zooplankton in both laboratory and microcosm exposures. The researchers reported 8-14 fold synergy in microcosms after 2 and 7 days and 3-7 fold synergy in 2 day laboratory exposures of *Daphnia magna* (Bjergager et al. 2012). In microcosms, abundance of cladocerans, copepods, and chironomids was reduced more in treatments with both prochloraz and esfenvalerate compared to those treated with solely esfenvalerate (Bjergager et al. 2011). These studies demonstrated that synergistic effects observed in laboratory conditions also occur in field conditions at similar levels and that these effects can last for several weeks.

No studies on aquatic organisms were identified in the literature that could provide a quantitative means to consider mixtures of esfenvalerate with other classes of pesticides. Although there are examples of non-additive toxicity for esfenvalerate and other chemicals, a multispecies interaction coefficient is not available for any chemical with esfenvalerate, and therefore the concentrations of non-additive chemicals cannot be used for criteria compliance (section 3-5.2.2, TenBrook et al. 2009).

9.3 Temperature, pH, and other water quality effects

Temperature, pH, and other water quality effects on the toxicity of esfenvalerate were examined to determine if any effects are described well enough in the literature to incorporate into criteria compliance (section 3-5.3, TenBrook et al. 2009). Temperature has been found to be inversely proportional to the aquatic toxicity and bioavailability of pyrethroids (Miller & Salgado 1985, Werner & Moran 2008). In fact, the increase of toxicity of pyrethroids with decreasing temperature has been used to implicate pyrethroids as the source of toxicity in environmental samples (Phillips et al. 2004, Weston et al. 2009). The inverse relationship between temperature and pyrethroid toxicity is likely due to the increased sensitivity of an organism's sodium channels at low temperatures (Narahashi et al. 1998).

The toxicities of six aqueous pyrethroids (cypermethrin, permethrin, fenvalerate, *d*-phenothrin, flucythrinate, and bioallethrin) were 1.33- to 3.63-fold greater at 20˚C compared to 30 ˚C for mosquito larvae (Cutkomp and Subramanyam 1986). Harwood et al. (2009) tested lambda-cyhalothrin and permethrin toxicity to *Chironomus dilutus* in an aqueous exposure at 13˚C and 23˚C, and reported a 3.2-fold decrease of the 96-h LC_{50} at the lower temperature. Kumaraguru and Beamish (1981) reported that for small trout, toxicity of permethrin increased by a factor of 10 with a decrease in temperature from 20˚C to 5˚C, but showed little change from 10˚C to 5˚C. Toxicity of sediment-bound esfenvalerate to *Hyalella azteca* at 18˚C and 23˚C were reported by Weston et al. (2009). The 10-day LC_{50} at 18˚C was 1.06 (0.85-1.31) μg/g OC, which was a factor of 1.9 lower than the LC_{50} at 23˚C of 2.00 (1.64-2.34) μg/g OC.

Conversely, Materna et al. (1995) reported that esfenvalerate was less toxic to leopard frogs (*Rana* spp.) at 18˚C (LC_{50} > 11.47 μg/L) compared to 22˚C (LC_{50}=7.29 μg/L). The authors note that these results conflict with other published studies of temperature effects on pyrethroid toxicity and postulated that the increased toxicity at the higher temperature may be due to metabolic depletion of energy reserves in tadpoles, which were not fed in the 96-hour test, and the decrease in energy reserves may have reduced survival. Most studies on pyrethroids and temperature indicate that there are enhanced toxic effects of pyrethroids at lower temperatures. This effect may not be accurately represented by the results of typical laboratory toxicity tests, which tend to be run at warmer temperatures, 20-23˚C (USEPA 1996a, USEPA 1996b, USEPA 2000), than those of the habitats of coldwater fishes, about 15˚C or lower (Sullivan et al. 2000).

Unfortunately, there are limited data demonstrating increased toxicity at lower temperatures using aquatic exposures with relevant species, making it unfeasible to quantify the relationship between the toxicity of permethrin and temperature for water quality criteria at this time (section 3-5.3, TenBrook et al. 2009). Several studies that examined the effects of DOC and suspended solids on esfenvalerate toxicity are discussed in the bioavailability section. No other studies on esfenvalerate were identified that examined the effects of pH or other water quality parameters on toxicity, thus, there is no way to incorporate any of these parameters into criteria compliance.

10 Comparison of ecotoxicity data to derived criteria

10.1 Sensitive species

A data comparison was conducted to assess if the derived criteria for esfenvalerate are protective of the most sensitive species. The derived WQC are compared to toxicity values for the most sensitive species in both the acceptable (RR) and supplemental (RL, LR, LL) data sets. The lowest acute toxicity value in the aqueous data sets is a LC_{50} of 49 ng/L for *Ceriodaphnia dubia.* The acute WQC of 20 ng/L is more than a factor of 2 below this LC_{50} and would likely be protective of this species. There is also a 48-h LOEC of 20 ng/L for *Baetis* spp. based on hatching success of exposed eggs (Palmquist et al. 2008b). This LOEC is equal to the acute WQC, indicating that there may be some risk for sensitive insect species at the acute WQC. The acute WQC will not be adjusted downward based on this toxicity value because this toxicity value is considered a chronic value, and the chronic WQC of 3 ng/L would be protective of this sensitive species.

The lowest chronic toxicity value is a MATC of 17 ng/L for bluegill sunfish based on the endpoint of tremors per minute (Little et al. 1993). The chronic WQC of 3 ng/L is below this value and would be protective of this species. It should be noted that there are no data available for *Hyalella azteca,* which is known as a species that is particularly sensitive to pyrethroids. It is

not clear if the derived WQC would be protective of these amphipods. If acceptable toxicity data for *H. azteca* become available, the WQC should be re-calculated to include this species.

The interim BSQC are compared to toxicity values for the most sensitive species in both the acceptable (RR) and supplemental (RL, LR, LL) data sets. The lowest reported acute sediment toxicity value in all data sets is the 10-d LC_{50} of 0.29 μg/g OC for *H. azteca* (Picard 2010b; Table 8). The interim acute BSQC of 0.012 μg/g OC is a factor of 24 below this value, indicating that the interim BSQC is very protective of *Hyalella azteca*.

Many of the SSTT studies used to calculate the acute BSQC also reported NOEC or LOEC values for the 10-day study. Since 10-day NOEC/LOECs do not meet the requirements for inclusion in the acute data set (which requires LC/EC_{50}s) or the chronic data set (which requires 28-d full or partial life cycle tests), these values were not used for derivation of BSQC, but are compared to the derived BSQC. The lowest MATC reported for *H. azteca* is 0.23 μg/g OC based on a 10-d survival endpoint (Picard et al. 2010b). The interim acute BSQC is below all of these values and thus can be considered protective. The only available chronic SSTT data are for the saltwater species *Leptocheirus plumulosus* (Table 10). The 28-day MATC for esfenvalerate is 1.5 μg/g OC (Putt 2005b). This value is well above the interim chronic BSQC and would be protective of *L. plumulosus*.

10.2 Ecosystem studies

The derived criteria are compared to acceptable laboratory, field, or semi-field multispecies studies (rated R or L) to determine if the criteria will be protective of ecosystems (section 3-6.2, TenBrook et al. 2009). Twelve studies describing effects of esfenvalerate on mesocosm, microcosm and model ecosystems were identified and rated for reliability according to the UCDM (Table 3.9, TenBrook et al. 2009). Four studies were rated as reliable (R; Faircheld et al. 1992, Stampfli et al. 2011, Stampfli et al. 2013, Webber et al. 1992) and five studies were rated as less reliable (L; Fairchild et al. 1994, Krueger et al. 1990, Lozano et al. 1992, Palmquist et al. 2008, Samsoe-Petersen et al. 2001) and are used as supporting data. Three studies rated as not reliable (N) and are not discussed in this report (Forbes & Cold 2005, Heinis & Knuth 1992, Stay & Jarvinen 1995). Stampfli et al. (2011) reported a community NOEC of 0.3 μg/L, which is two orders of magnitude higher than the chronic WQC of 0.003 μg/L. No other studies reported community NOECs. Most of the reported test concentrations (0.005-50 μg/L) were higher than the chronic WQC of 0.003 μg/L, but one study reported effects at 0.005 μg/L (Samsoe-Petersen et al. 2001), which is less than a factor of 2 higher than the chronic WQC. Effects based on sediment concentrations were reported in two studies. Lozano et al. (1992) reported effects benthic macroinvertebrates 10 μg/g; the organic carbon content was not reported, but if 1% OC is assumed, then the concentration would be 1,000 μg/g OC. Webber et al. (1992) reported effects on benthic invertebrates at 56.3 μg/kg and no effects were observed at 11.4 μg/kg. Sediment OC content was not reported, but assuming 1% OC, these concentrations would

convert to 5.63 μg/g OC and 1.14 μg/g OC. All of the reported sediment concentrations are much higher than the interim chronic BSQC of 0.0021 μg/g OC, thus the BSQC would be very protective based on these study results. The studies rated R and L are summarized below.

Fairchild et al. (1992) exposed artificial pond mesocosms containing bluegill fish, macroinvertebrates, zooplankton, phytoplankton, and macrophytes to three concentrations of esfenvalerate. There were six treatments at 2-week intervals. Zooplankton and macroinvertebrates were affected by nominal aqueous esfenvalerate concentrations of 0.25 μg/L, which was the lowest tested concentration. Bluegills were affected at the next highest nominal aqueous concentration 0.67 μg/L and above; reduced survival, biomass production, adult male survival rate, and reproductive success were observed. It appeared that reproductive stress (i.e., energy costs associated with reproductive activities) increased the sensitivity of adult male bluegills to short-term insecticide exposure. The multiple pulsed dosing did not seem to result in cumulative effects to bluegills. Esfenvalerate exposure decreased cladoceran and copepod populations, and subsequently rotifers increased, likely due to decreased competition and predation. Zooplankton recovered in as little as 2 weeks post-treatment in some cases, likely because they have a shorter generation time and a source of recolonization in the sediment. Laboratory toxicity tests conducted to compare to the mesocosms indicated that the laboratory toxicity to *Daphnia* underestimated effects in the mesocosms. For bluegills, the laboratory tests closely estimated toxicity observed in the mesocosms. Using the same mesocosm setup, Fairchild et al. (1994) tested artificial pond mesocosms to five concentrations of esfenvalerate. There was one set of treatments with just esfenvalerate, and another set of treatments with esfenvalerate and 50 μg/L of atrazine to test for mixture effects. Pre-treatment, copepods dominated the zooplankton community. Total zooplankton density was reduced post-treatment, and copepods and cladocera recovered within 7 days because esfenvalerate dissipated quickly. No differences were observed between treatments with and without atrazine. The number of bluegill young decreased with increasing esfenvalerate concentrations, but there were no effects on survival or growth of adults.

Webber et al. (1992) exposed artificial pond mesocosms with bluegill, macroinvertebrates, zooplankton, phytoplankton, and macrophytes to three concentrations of esfenvalerate and controls. The esfenvalerate applications mimicked spray drift with weekly applications and runoff with biweekly applications. Changes in the ecosystem structure and function were related to predator-prey interactions among phytoplankton, zooplankton, and young bluegills. Esfenvalerate exposure reduced microcrustacean zooplankton abundance, while rotifers were unaffected and increased post-treatment. Benthic macroinvertebrates were reduced in the highest treated concentration. The only effects on bluegills were reduced trapping of 2-cm size class fish in the highest concentration, perhaps because microcrustaceans, their main food source, were limited post-treatment. The measured concentrations of the three treatment levels were 0.01, 0.18, and 0.69 μg/L in water and 6.4, 11.4, and 56.3 μg/kg in sediment.

Lozano et al. (1992) applied esfenvalerate to littoral enclosures in a pond containing bluegills, benthic macroinvertebrates, zooplankton, phytoplankton, and macrophytes. They made two applications 4 weeks apart at nominal concentrations of 0.01, 0.08, 0.2, 1, and 5 μg/L. For most aquatic organisms in the littoral zone, acute effects occurred in the first 4 days because aqueous esfenvalerate dissipates (degrades and sorbs to sediment) during that time. Sediment concentrations were highest after the second application, measured at 10 μg/g dry weight. Recovery was lower after the second application for copepods, *H. azteca*, and aquatic insects, perhaps due to accumulation in sediments.

Samsoe-Petersen et al. (2001) investigated effects of esfenvalerate on zooplankton in enclosures in natural lake. Copepods and cladocerans abundance was reduced in the lowest treatment, a nominal aqueous concentration of 0.005 μg/L, and all higher concentrations (ranging up to 26 μg/L). As copepods and cladocerans decreased, rotifers increased significantly.

Krueger et al. (1990) reported effects on total phytoplankton abundance, biomass, and primary production in ponds treated with esfenvalerate. Total phytoplankton abundance, biomass, and primary production increased in high treatment group after esfenvalerate treatment, which is attributed to greater densities of Chlorophyta and Euglenophyta during and after treatment period. No phytoplankton increases were observed in low and medium treatment ponds. Total zooplankton density was not reduced post-treatment. During application, copepod nauplii density and total zooplankton biomass decreased significantly in the medium and high treatments. However, post-treatment, zooplankton recovered to levels similar to controls. Abundance in dredge samples (benthos) was significantly reduced in the high treatment compared to control during treatment and post-treatment.

Stampfli et al. (2011) tested outdoor microcosms containing algal and macroinvertebrate populations with single treatments of esfenvalerate (nominal 0.03, 0.3, 3 μg/L). Three different regimes were tested, with some microcosms in full sun and some shaded, and harvesting of algae and macroinvertebrates at regular intervals was another experimental variable tested, which simulated harvesting by predators. The researchers calculated NOECs and LOECs based on community structure for the three different regimes tested for various times, ranging from 4 to 71 days post-treatment. The NOECs ranged from <0.03 to 0.3 μg/L for the time range post-treatment and shading/harvesting regime. However, at 71-d post-treatment, the NOEC for all regimes was 0.3 μg/L. A similar study conducted by this group tested the same three levels of esfenvalerate with three regimes of fluctuating water levels in the pond microcosms to simulate climate change effects (Stamplfli et al. 2013). In this study LOECs of 0.03 and 0.3 μg/L were reported for microcosms with fluctuating and constant water levels, respectively, based on altered community structure. LOECs were also reported for abundance of *Daphnia* spp. that are equal to the community-level LOECs.

10.3 Threatened and endangered species

The derived criteria are compared to measured toxicity values for threatened and endangered species (TES), as well as to predicted toxicity values for TES, to ensure that they will be protective of these species. Current lists of state and federally listed threatened and endangered plant and animal species in California were obtained from the California Department of Fish and Wildlife (CDFW) website (http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf; CDFW 2013).

One listed animal species is represented in the acute WQC data set. Five Evolutionarily Significant Units of *Oncorhynchus mykiss* are listed as federally threatened or endangered throughout California. The acute data set includes a SMAV for *O. mykiss* of 0.26 μg/L calculated from a study rated RR. The supplemental data set includes a 96-h LC_{50} for *O. tshawytscha* of 16.7 μg/L from a study rated RL (Viant et al. 2006).

There are listed species that are represented in the acute toxicity data set by members of the same family or genus. *Oncorhynchus mykiss* can serve as a surrogate in estimates for other species in the same family using the USEPA interspecies correlation estimation website (Web-ICE v. 3.2.1; Raimondo et al. 2013). Table 11 summarizes the results of the ICE analyses. The estimated acute toxicity values in Table 11 range from 0.266 μg/L for Coho salmon to 0.397 μg/L for other endangered salmonids. Based on the available data and estimated values for TES, there is no evidence that the calculated acute and chronic WQC will be underprotective of threatened and endangered species.

No listed threatened or endangered species are included in the acceptable and supplemental data sets used for esfenvalerate BSQC derivation (Table 8 and Table 10). No data were found for effects of sediment-associated esfenvalerate on federally endangered crustaceans and insects, or acceptable surrogates (i.e., in the same family). The interim acute and chronic BSQC were converted to interstitial concentrations of 0.075 ng/L and 0.013 ng/L, respectively, to compare to the aqueous toxicity values for TES. The acute and chronic BSQC are far below the toxicity value for rainbow trout (260 ng/L). Based on the little available data, there is no evidence that the interim acute and chronic esfenvalerate BSQC will be under-protective of threatened or endangered species but this assessment lacks chronic data and data for crustaceans and insects, which are considered the most sensitive species.

11 Harmonization with other environmental media

11.1 Bioaccumulation

Bioaccumulation was assessed to ensure that the derived criteria will not lead to unacceptable levels of esfenvalerate in food items (section 3-7.1, TenBrook et al. 2009). Esfenvalerate has a log K_{ow} of 5.9 and a molecular weight of 419.9 (section 3), which indicates it has bioaccumulative potential (section 3-7.1, TenBrook et al. 2009). No biomagnification factor (BMF) values were found in the literature for esfenvalerate, but bioconcentration of esfenvalerate has been measured in several studies (Table 1).

To check that these criteria are protective of terrestrial wildlife that may consume aquatic organisms, a bioaccumulation factor (BAF) was used to estimate the water concentration that would roughly equate to a reported toxicity value for consumption of fish by terrestrial wildlife. These calculations are further explained in section 3-7.1 of the methodology (TenBrook et al. 2009). The BAF of a given chemical is the product of the bioconcentration factor (BCF) and a BMF, such that BAF=BCF*BMF. For a conservative estimate, the highest fish BCF of 3,870 L/kg for *Cyprinus carpio* (Table 1) and a default BMF of 10, chosen based on the log K_{ow} of esfenvalerate (Table 3.15, TenBrook et al. 2009), were used to calculate a BAF. A chronic dietary NOEC for an oral predator is preferred for this calculation because it is the most realistic value for extrapolation to bioaccumulation in the environment (section 3-7.1, TenBrook et al. 2009), so the dietary NOEC for mallard duck of 562 mg/kg was used (Driscoll 1990).

$$NOEC_{water} = \frac{NOEC_{oral\_predator}}{BCF_{food\_item} * BMF_{food\_item}}$$

Mallard:
$$NOEC_{water} = \frac{562\ ^{mg}/_{kg}}{3870\ ^{L}/_{kg} * 10} = 0.0145\ ^{mg}/_{L} = 14.5\ ^{\mu g}/_{L}$$

In this example, the chronic WQC of 3 ng/L is a factor of 4833 below the estimated $NOEC_{water}$ for mallard, and is not likely to cause adverse effects to terrestrial wildlife. The chronic interstitial water BSQC of 0.013 ng/L is also below the $NOEC_{water}$ for mallards. Bioaccumulation of esfenvalerate is not likely because the $NOEC_{water}$ exceeds the aqueous solubility of esfenvalerate (4 μg/L, see section 3). This analysis indicates that terrestrial wildlife will not likely be harmed by bioaccumulation of esfenvalerate if the WQC and interim BSQC are attained.

11.2 Air, Sediment, Water, etc.

This section addresses how the maximum allowable concentration of esfenvalerate might impact life in other environmental compartments through partitioning (section 3-7.2, TenBrook et al. 2009). However, there are no federal or state sediment or air quality standards for esfenvalerate (CARB 2005, CDWR 1995, USEPA 2006b, USEPA 2006c) to enable this kind of extrapolation. For biota, the limited data on bioconcentration or biomagnification of esfenvalerate were addressed in the bioaccumulation section (11.1).

The BSQC were converted from OC-normalized sediment concentrations to interstitial water concentrations to compare them to existing water quality criteria. The K_{OC} of 161,000, which is the geometric mean of 11 values (section 3), was used as the partition coefficient. The resulting interim acute and chronic BSQC interstitial concentrations were 0.075 ng/L and 0.013 ng/L, respectively. The esfenvalerate acute and chronic WQC are 20 ng/L and 3 ng/L, respectively, which are above the BSQC concentrations. Therefore, if the BSQC were attained it would be unlikely that the WQC would be exceeded due to desorption from sediment, if equilibrium conditions are assumed.

12 Esfenvalerate Criteria Summary

12.1 Assumptions, limitations, uncertainties

The assumptions, limitations and uncertainties involved in criteria derivation should be available to inform environmental managers of the accuracy and confidence in the derived criteria. This section summarizes any data limitations that affected the procedure used to determine the final esfenvalerate criteria.

There were enough highly rated acute esfenvalerate data to use a SSD to calculate the acute WQC, but one limitation in the data set is that not all of the data are from flow-through tests that use measured concentrations to calculate the toxicity values. Flow-through tests and measurement of concentrations are particularly important in tests with pyrethroid pesticides because they are highly sorptive. None of the acute RR data are from flow-through tests, and only three of the eight SMAVs were based on measured concentrations. Another limitation in the acute WQC data set is that there were no data available for *Hyalella azteca*, which is known to be a particularly sensitive species, therefore it is not clear if the WQC will be protective of this species. Uncertainty of the acute WQC can be quantified by looking at the lower 95% confidence limit (section 7.1).

For esfenvalerate, as with other pyrethroids, a major limitation was in the chronic toxicity data set. Two of five taxa requirements were not met (salmonid and benthic crustacean), which

precluded the use of a SSD; therefore, an ACR was used to derive the chronic WQC. There was one set of paired data available to calculate an empirical ACR for *Daphnia magna*, so this ACR was used with default ACRs for the other two ACR requirements (as specified in section 3-4.2.2, TenBrook et al. 2009). Particularly of concern for the chronic toxicity data set was the lack of data on *Hyalella azteca* or another benthic organism, which is known to be a sensitive species for pyrethroids. Uncertainty cannot be quantified for the chronic WQC because it was derived using an ACR, not an SSD.

For the esfenvalerate acute BSQC, a major limitation was the lack of acute SSTT data for freshwater species other than *H. azteca* and *C. dilutus*. Three of the five taxa requirements of the UCDSM were not met, and as such, an assessment factor approach was used to calculate the acute BSQC. The major limitation for the esfenvalerate chronic BSQC derivation was the lack of any freshwater species in the chronic toxicity data set. None of five taxa requirements were met, which precluded the use of a SSD; therefore, an ACR was used to derive the chronic criterion. Since no acceptable experimental ACRs were available, the default ACR of 11.4 was used. Particularly of concern was the lack of chronic data for *H. azteca,* which was the most sensitive species in the acute toxicity data set. Uncertainty cannot be quantified for either the acute or chronic criteria because they were not derived with a SSD.

To compare the OC-normalized sediment BSQC to relevant aqueous concentrations, the BSQC were converted to interstitial water concentrations using the K_{OC} of 161,000, which is the geometric mean of 11 values (section 3). The resulting acute and chronic interstitial concentrations were 0.075 ng/L and 0.013 ng/L, respectively.

The effect of increased toxicity at lower temperatures could not be accounted for quantitatively in criteria compliance. It can be noted that the three most sensitive species in the acute WQC data set were tested at lower temperatures ranging from 11-13 ˚C, so this effect is accounted for in the criteria to some degree. However, because many streams in the California Central Valley often have lower water temperatures, it may be appropriate to apply an additional safety factor to the esfenvalerate criteria for those areas to ensure adequate protection. If colder water bodies are impacted by concentrations of esfenvalerate, a rough factor of two could be estimated from a study by Weston et al. (2009). It would be preferable derive such an adjustment factor based on studies relating temperature to aqueous toxicity of esfenvalerate in multiple species, including *Hyalella azteca*. We do not recommend an additional safety factor to account for temperature effects at this time, but environmental managers may want to consider this application if the criteria do not appear to be protective of organisms in a colder water body. If aquatic exposure data for multiple species demonstrating temperature effects become available in the future, a regression equation describing the effect should be incorporated into criteria compliance.

Although greater than additive effects have been observed for mixtures of pyrethroids and other pesticides and synergists, there are insufficient data to account for this interaction for

compliance determination. This is a significant limitation because formulations that contain both pyrethroids and PBO are now available on the market and applications of pyrethroids may overlap with other synergistic pesticides. When additional highly rated data are available, the criteria should be recalculated to incorporate new research.

12.2 Comparison to EPA method and other criteria

This section provides a comparison between UCDM WQC and the USEPA 1985 guidelines for WQC derivation (USEPA 1985). The esfenvalerate data set generated in this report was examined for use with the USEPA 1985 guidelines. The USEPA acute method has three additional taxa requirements beyond the five required by the UCDM, they are:

1. A third family in the phylum Chordata (e.g., fish, amphibian);
2. A family in a phylum other than Arthropoda or Chordata (e.g., Rotifera, Annelida, Mollusca);
3. A family in any order of insect or any phylum not already represented.

One out of three of these additional requirements are met as follows:

1. A third family in the phylum Chordata is met with data from fathead minnow (*Pimephales promelas*) or striped bass (*Morone saxatilis*).
2. This requirement is not met becauase all data are from organisms in the phylum Arthropoda or Chordata.
3. This requirement is not met because there are no additional insect data and no data for other phyla not already represented.

The USEPA 1985 guidelines cannot be used to calculate an acute criterion for esfenvalerate because two of the eight taxa requirements are not met. The California Department of Fish and Wildlife (formerly Fish and Game) have used data sets that met only seven of eight requirements in the USEPA methodology when the missing taxon was known to be insensitive. The missing taxa for esfenvalerate are not known to be insensitive to esfenvalerate, thus an acute WQC will not be calculated with the USEPA 1985 guidelines. The chronic data set is also deficient, only meeting three of the eight taxa requirements of the USEPA 1985 guidelines, which are the same three met in the UCDM.

To date, no USEPA sediment criteria or benchmarks are available for esfenvalerate. The USEPA proposes an EqP-based approach, through which, the chronic WQC is used to predict the corresponding sediment concentration using the K_{OC} (Di Toro et al. 2002). The lowest SMAV in the acceptable sediment data set was converted to an interstitial water concentration to compare it to existing WQC. The lowest SMAV in the RR data set of 0.29 μg/g OC for *H. azteca* (Table 8) was converted to an interstitial concentration of 1.8 ng/L using the geometric mean of K_{OC}s of 161,000. This sediment SMAV of 1.8 ng/L is compared to the chronic WQC for esfenvalerate of 3 ng/L; the WQC is a factor of 1.67 higher than the lowest sediment SMAV. Thus, the chronic

WQC may not be protective of short-term effects from sediment-associated esfenvalerate. There are no chronic esfenvalerate sediment effects data available, but it is unlikely that the chronic WQC would be protective of long-term sublethal effects.

12.3 Final criteria statements

The final water quality criteria statement is:

Aquatic life should not be affected unacceptably if the four-day average concentration of esfenvalerate does not exceed 0.003 μg/L (3 ng/L) in the water column more than once every three years on average and if the one-hour average concentration does not exceed 0.02 μg/L (20 ng/L) more than once every three years on average. Mixtures of esfenvalerate and other pyrethroids should be considered in an additive manner (see Mixtures section 9.2).

The interim bioavailable sediment quality criteria statement is:

Aquatic life should not be affected unacceptably if the 28-day average concentration of esfenvalerate does not exceed 0.0021 μg/g OC in sediment more than once every three years on average and if the 10-day average concentration does not exceed 0.012 μg/g OC more than once every three years on average. Mixtures of esfenvalerate and other pyrethroids should be considered in an additive manner (see Mixtures section 9.2).

Although the criteria were derived to be protective of aquatic life in the Sacramento and San Joaquin Rivers, these criteria would be appropriate for any freshwater ecosystem in North America, unless species more sensitive than are represented by the species examined in the development of the present criteria are likely to occur in the ecosystems of interest.

The final acute WQC was derived using the log-logistic SSD procedure (section 7.1) and the acute data used in criteria calculation are shown in Table 3. The chronic criterion was derived by use of an ACR calculated from a combination of measured data and default ACRs (section 8.1); chronic data rated RR are shown in Table 5. It is recommended that the freely dissolved esfenvalerate concentration is measured for WQC compliance because this appears to be the best predictor of the bioavailable fraction (section 9.1).

The interim acute BSQC was derived using the AF procedure is described in section 7.2 and the acute data used in criteria calculation are shown in Table 8. The interim chronic BSQC was derived by use of a default ACR (section 8.2). The BSQC are considered interim because there are very few SSTT data available for pesticides, and because of this it was not possible to fully test the UCDSM with larger SSTT data sets and a high degree of uncertainty remains in any BSQC derived with the method.

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Data Tables

Table 3 Final acute toxicity data used to calculate esfenvalerate WQC.
All studies were rated relevant and reliable (RR).

Species	Common name	Family	Test type	Duration (d)	Temp (°C)	Endpoint	Age/ size	Nom/ Meas	LC/EC_{50} (95% CI) (µg/L)	Reference
Baetis spp.	Mayfly	Baetidae	S	48 h	11	Survival	Early stage eggs	Nom	**0.169**	Palmquist et al. 2008b
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.058 (0.050-0.067)	Yang et al. 2006
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.049 (25 mg/L SS)	Yang et al. 2006
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.039 (0.011-0.076) (35 mg/L SS)	Yang et al. 2006
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.112 (0.072-0.153) (25 mg/L SS)	Yang et al. 2006
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.088 (0.052-0.129) (25 mg/L SS)	Yang et al. 2006
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.092 (0.067-0.126) (50 mg/L)	Yang et al. 2006
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.105 (0.066-0.154) (50 mg/L SS)	Yang et al. 2006
Ceriodaphnia dubia						Survival	Geometric mean		**0.073**	
Daphnia magna	Daphnid	Daphniidae	S	48 h	20 ± 0.2	Immobility	< 24 h	Nom	0.90 (0.70-1.16)	Hutton 1987a
Daphnia magna	Daphnid	Daphniidae	SR	48 h	19.75	Immobility	< 24 h	Meas	0.24 (0.19-0.30)	Baer 1992a
Daphnia magna						Immobility	Geometric mean		**0.46**	

Species	Common name	Family	Test type	Duration (d)	Temp (°C)	Endpoint	Age/ size	Nom/ Meas	LC/EC_{50} (95% CI) (µg/L)	Reference
Gammarus pulex	Amphipod	Gammaridae	S	96 h	13	Survival	Small adult (7-8 mm length)	Nom	0.138 (0.128-0.151)	Cold & Forbes 2004
Gammarus pulex	Amphipod	Gammaridae	S	96 h	13	Survival	Large adult (10-14 mm length)	Nom	0.132 (0.122-0.145)	Cold & Forbes 2004
Gammarus pulex						Survival	Geometric mean		**0.135**	
Lepomis macrochirus	Bluegill sunfish	Centrachidae	S	96 h	22±1	Survival	0.19 g, 25 mm	Nom	**0.26** (0.20-0.36)	Forbis et al. 1985a
Morone saxatilis	Striped bass	Moronidae	S	24 h	20.3	Survival	Juvenile, 81-d	Meas	**2.17**	Geist et al. 2007
Oncorhynchuss mykiss	Rainbow trout	Salmonidae	S	96 h	11±1	Survival	0.56 g, 41 mm	Nom	**0.26** (0.20-0.38)	Forbis et al. 1985b
Pimephales promelas	Fathead minnow	Cyprinidae	SR	96 h	20	Survival	7 d	Meas	Test 1: 0.18 Test 2: 0.22 Test 3: 0.22	Denton et al. 2003
Pimephales promelas						Survival	Geometric mean		**0.21**	

Nom: Toxicity value calculated with nominal concentrations, Meas: Toxicity values calculated with measured concentrations, LC_{50}: exposure concentration lethal to 50% of a test population, EC_{50}: exposure concentration that causes effect in 50% of a test population.

Table 4 Aqueous esfenvalerate acute toxicity data reduced from final data set.
All studies were rated relevant and reliable (RR).

Species	Common name	Family	Test type	Duration (d)	Temp (°C)	Endpoint	Age/ size	Nom/ Meas	LC/EC_{50} (95% CI) (µg/L)	Reference	Reason for reduction
Ceriodaphnia dubia	Daphnid	Daphniidae	SR	24 h	20	Survival	< 24 h	Nom	2.4	Brander et al. 2012	2
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.106 (0.060-0.155) (50 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.167 (0.110-0.258) (50 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.144 (0.082-0.218) (100 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.145 (0.099-0.240) (100 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.213 (0.118-0.354) (100 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.187 (0.133-0.296) (100 mg/L)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.302 (0.202-0.439) (200 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 + 1	Survival	< 24 h	Meas	0.349 (0.246-0.503) (200 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 ± 1	Survival	< 24 h	Meas	0.363 (0.252-0.523) (200 mg/L SS)	Yang et al. 2006	1
Ceriodaphnia dubia	Daphnid	Daphniidae	S	96 h	21 + 1	Survival	< 24 h	Meas	0.270 (0.212-0.350) (200 mg/L SS)	Yang et al. 2006	1

Species	Common name	Family	Test type	Duration (d)	Temp (°C)	Endpoint	Age/ size	Nom/ Meas	LC/EC_{50} (95% CI) (µg/L)	Reference	Reason for reduction
Daphnia magna	Daphnid	Daphniidae	S	24 h	20 ± 0.2	Immobility	< 24 h	Nom	3.7 (2.7-7.1)	Hutton 1987a	2
Gammarus pulex	Amphipod	Gammaridae	S	24 h	13	Survival	Small adult (7-8 mm length)	Nom	0.236 (0.216-0.259)	Cold & Forbes 2004	2
Gammarus pulex	Amphipod	Gammaridae	S	48 h	13	Survival	Small adult (7-8 mm length)	Nom	0.137 (0.127-0.151)	Cold & Forbes 2004	2
Gammarus pulex	Amphipod	Gammaridae	S	24 h	13	Survival	Large adult (10-14 mm length)	Nom	0.340 (0.308-0.376)	Cold & Forbes 2004	2
Gammarus pulex	Amphipod	Gammaridae	S	48 h	13	Survival	Large adult (10-14 mm length)	Nom	0.142 (0.131-0.155)	Cold & Forbes 2004	2
Lepomis macrochirus	Bluegill sunfish	Centrachidae	S	48 h	22±1	Survival	0.19 g, 25 mm	Nom	0.38 (0.29-0.57)	Forbis et al. 1985a	2
Pimephales promelas	Fathead minnow	Cyprinidae	SR	48 h	20	Survival	7 d	Meas	0.30	Denton et al. 2003	2
Pimephales promelas	Fathead minnow	Cyprinidae	SR	72 h	20	Survival	7 d	Meas	0.26	Denton et al. 2003	2

1. Non-standard conditions
2. Later time points available (duration <96 h)

Table 5 Final chronic toxicity data used to calculate esfenvalerate WQC.
All studies were rated relevant and reliable (RR).

Species	Common name	Family	Test type	Duration (d)	Temp (°C)	Endpoint	Age/ size	Nom/Meas	MATC (µg/L)	Reference
Baetis spp.	Mayfly	Baetidae	S	48 h	11	Hatching success	Late-term eggs	Meas	LOEC: **0.02**	Palmquist et al. 2008b
Daphnia magna	Daphnid	Daphniidae	SR	21 d	20 ± 1	Reproduction (# of young & young/d), Growth (length)	< 24 h	Meas	**0.064**	Hutton 1987b
Lepomis macrochirus	Bluegill sunfish	Centrarchidae	FT	90 d	22	Survival	Juvenile (1.01 g, 41 mm length)	Meas	**0.069**	Little et al. 1993

LC_{50}: exposure concentration lethal to 50% of a test population, EC_{50}: exposure concentration that causes effect in 50% of a test population.

Table 6 Aqueous esfenvalerate chronic toxicity data reduced from final data set.
All studies were rated relevant and reliable (RR).

Species	Common name	Family	Test type	Duration (d)	Temp (°C)	Endpoint	Age/ size	Nom/ Meas	LC/EC_{50} (95% CI) (µg/L)	Reference	Reason for reduction
Baetis spp.	Mayfly	Baetidae	S	48 h	11	Hatching success	Early-stage eggs	Meas	LOEC: 0.0658	Palmquist et al. 2008b	1
Daphnia magna	Daphnid	Daphniidae	SR	21 d	20 ± 1	Survival	< 24 h	Meas	0.11	Hutton 1987b	2
Lepomis macrochirus	Bluegill sunfish	Centrarchidae	FT	30 d	22	Survival	Juvenile (1.01 g, 41 mm length)	Meas	0.13	Little et al. 1993	3
Lepomis macrochirus	Bluegill sunfish	Centrarchidae	FT	60 d	22	Survival	Juvenile (1.01 g, 41 mm length)	Meas	0.069	Little et al. 1993	3

1. More sensitive life-stage available
2. More sensitive endpoint available
3. Longer duration available

Table 7 Supplemental studies for the esfenvalerate water quality criteria derivation.

Species	Common name	Test Type	Duration (d)	Temp (°C)	Endpoint	Age/size	Nom/ Meas	LC/EC$_{50}$ (µg/L)	MATC (µg/L)	Ref	Rating, Excl.
Baetis spp.	Mayfly	S	48 h	11	Hatching success	Early-stage eggs	Meas	-	NOEC: < 0.0658	Palmquist et al. 2008b	LR, 5
Baetis spp.	Mayfly	S	48 h	11	Hatching success	Late-term eggs	Meas	-	NOEC: < 0.02	Palmquist et al. 2008b	LR, 5
Brachycentrus americanus	Caddisfly	S	48 h	11	Case abandonment	5th instar	Nom	-	0.07	Johnson et al. 2008	LL, 1, 2, 3
Brachycentrus americanus	Caddisfly	S	48 h	11	Post-hatch survival	Early-stage eggs	Meas	-	1.4	Palmquist et al. 2008b	LL, 1, 2, 3
Chironomus dilutus	Midge (insect)	S	96 h	21	Mobility	Late 3rd-early 4th instar	Nom	0.21 (0.16-0.27)	EC$_{10}$: 0.078 (0.040-0.111)	Belden & Lydy 2006	LL, 1, 2
Daphnia carinata	Daphnid	SR	6 d	20	Survival	< 24 h	Nom	-	224	Barry et al. 1995	LL, 1, 2, 4
Daphnia carinata	Daphnid	SR	6 d	20	Growth (Carapace length)	< 24 h	Nom	-	71	Barry et al. 1995	LL, 1, 2, 4
Daphnia carinata	Daphnid	SR	6 d	20	Reproduction (# of eggs 1st brood)	< 24 h	Nom	-	71	Barry et al. 1995	LL, 1, 2, 4
Daphnia carinata	Daphnid	SR	>6 d	20	Growth (Carapace length)	< 24 h	Nom	-	22	Barry et al. 1995	LL, 1, 2, 4
Daphnia carinata	Daphnid	SR	>6 d	20	Reproduction (# of eggs 2nd brood)	< 24 h	Nom	-	22	Barry et al. 1995	LL, 1, 2, 4
Daphnia magna	Daphnid	S	48 h	20	Mobility	< 24 h	Nom	Test 1: 0.16 $\pm$ 0.03 Test 2: 0.05$\pm$ 0.01		Bjergager et al. 2012	RL, 2
Lepomis macrochirus	Bluegill sunfish	S	24 h	22$\pm$1	Survival	0.19 g, 25 mm	Nom	> 0.32	-	Forbis et al. 1985a	LR, 5

Species	Common name	Test Type	Duration (d)	Temp (°C)	Endpoint	Age/size	Nom/ Meas	LC/EC_{50} (µg/L)	MATC (µg/L)	Ref	Rating, Excl.
Lepomis macrochirus	Bluegill sunfish	FT	30 d	22	Tremors per min.	Juvenile (1.01 g, 41 mm length)	Meas	-	0.069	Little et al. 1993	LR, 6
Lepomis macrochirus	Bluegill sunfish	FT	60 d	22	Tremors per min.	Juvenile (1.01 g, 41 mm length)	Meas	-	0.017	Little et al. 1993	LR, 6
Lepomis macrochirus	Bluegill sunfish	FT	90 d	22	Tremors per min.	Juvenile (1.01 g, 41 mm length)	Meas	-	0.038	Little et al. 1993	LR, 6
Morone saxatilis	Striped bass	S	4 h	20.3	Swimming behavior	Juvenile, 81-d	Meas	EC_{25}: 3.88	-	Geist et al. 2007	LR, 6
Morone saxatilis	Striped bass	S	24 h	20.3	Swimming behavior	Juvenile, 81-d	Meas	EC_{25}: 1.07	-	Geist et al. 2007	LR, 6
Morone saxatilis	Striped bass	S	4 h	20.3	Swimming behavior	Juvenile, 81-d	Meas	-	3.1	Geist et al. 2007	LR, 6
Morone saxatilis	Striped bass	S	24 h	20.3	Swimming behavior	Juvenile, 81-d	Meas	-	1.2	Geist et al. 2007	LR, 6
Morone saxatilis	Striped bass	S	4 h	20.3	Survival	Juvenile, 81-d	Meas		NOEC: 6.5	Geist et al. 2007	RR, 7
Morone saxatilis	Striped bass	S	4 h	20.3	Survival	Juvenile, 81-d	Meas	-	LOEC: >6.5	Geist et al. 2007	LR, 5
Morone saxatilis	Striped bass	S	24 h	20.3	Survival	Juvenile, 81-d	Meas	-	1.2	Geist et al. 2007	RR, 7
Oncorhynchus mykiss	Rainbow trout	S	24 h	11±1	Survival	0.56 g, 41 mm	Nom	> 0.32	-	Forbis et al. 1985b	LR, 5
Oncorhynchus mykiss	Rainbow trout	S	48 h	11±1	Survival	0.56 g, 41 mm	Nom	> 0.18	-	Forbis et al. 1985b	LR, 5
Oncorhynchus tshawytscha	Chinook salmon	SR	96 h	10	Survival	Alevins	Nom	16.7	-	Viant et al. 2006	RL, 2

Species	Common name	Test Type	Duration (d)	Temp (°C)	Endpoint	Age/size	Nom/ Meas	LC/EC_{50} (µg/L)	MATC (µg/L)	Ref	Rating, Excl.
Pimephales promelas	Fathead minnow	SR	48 h	21	Mobility	< 24 h	Nom	0.44 (0.41-0.48)	EC_{10}: 0.31 (0.27-0.34)	Belden & Lydy 2006	LL, 1, 2
Rana spp.	Leopard frog	S	96 h	18	Convulsive behavior	Tadpoles, 6-8 d post-hatch	Meas	3.40		Materna et al. 1995	RL
Rana spp.	Leopard frog	S	96 h	20	Convulsive behavior	Tadpoles, 6-8 d post-hatch	Meas	4.85		Materna et al. 1995	RL
Rana spp.	Leopard frog	S	96 h	22	Convulsive behavior	Tadpoles, 6-8 d post-hatch	Meas	6.14		Materna et al. 1995	RL
Rana spp.	Leopard frog	S	96 h	22	Survival	Tadpoles, 6-8 d post-hatch	Meas	7.29		Materna et al. 1995	RL

1. Control not described and/or response not acceptable
2. Low reliability score
3. No standard method cited
4. Low or unreported chemical purity
5. Toxicity value not calculable
6. Endpoint not directly linked to survival, growth, reproduction
7. Does not fit into acute or chronic category based on exposure duration

Table 8 Final acute toxicity data used to calculate esfenvalerate BSQC.
All studies were rated relevant and reliable (RR).

Species	Common name	Family	Duration (d)	Temp (°C)	Endpoint	Age/ size	LC/EC_{50} (95% CI) (µg/g OC)	% OC	Reference
Chironomus dilutus	Midge (Insect)	Chir.	10	23±1	Growth	2nd instar	8.2 (6.4-10.4)	5.5	a
Chironomus dilutus	Midge (Insect)	Chir.	10	23±1	Growth	3rd instar	9.5 (8.6-11.4)	2.2	b
Chironomus dilutus	Midge (Insect)	Chir.			Geometric mean		**8.8**		
Hyalella azteca	Amphipod	Hyal.	10	23	Growth	6-10 d	**0.29** (0.27-0.30)	2.1	c

LC_{50}: exposure concentration lethal to 50% of a test population, EC_{50}: exposure concentration that causes effect in 50% of a test population, OC: organic carbon, Chir. = Chironomidae, Hyal. = Hyalellidae.
[a]Putt 2005a, [b]Picard 2010a, [c]Picard 2010b

Table 9 Reduced studies rated RR for esfenvalerate bioavailable sediment quality criteria derivation.

Species	Common name	Family	Duration (d)	Temp (°C)	Endpoint	Age/ size	LC/EC$_{50}$ (95% CI) (µg/g OC)	% OC	Reference	Excl.
Chironomus dilutus	Midge (Insect)	Chir.	10	23±1	Survival	2nd instar	20 (15-24)	5.5	a	1
Chironomus dilutus	Midge (Insect)	Chir.	10	23±1	Survival	3rd instar	23.2 (20.5-25.9)	2.2	b	1
Chironomus dilutus	Midge (Insect)	Chir.	Geometric mean							
Hyalella azteca	Amphipod	Hyal.	10	23	Survival	6-10 d	0.37 (0.34-0.41)	2.1	c	1

LC$_{50}$: exposure concentration lethal to 50% of a test population, EC$_{50}$: exposure concentration that causes effect in 50% of a test population, OC: organic carbon, Chir. = Chironomidae, Hyal. = Hyalellidae.
[a]Putt 2005a, [b]Picard 2010a, [c]Picard 2010b
[1]Data with more sensitive endpoint available

Table 10 Supplemental studies excluded from esfenvalerate bioavailable sediment quality criteria derivation.

Species	Common name	Family	Duration (d)	Temp (°C)	Endpoint	Age/size	LC/EC$_{50}$ (µg/g OC)	% OC	MATC (µg/g OC)	Ref	Rating, Excl.
Chironomus dilutus	Midge (Insect)	Chir.	10	23±1	Growth	2nd instar	-	5.5	3.4	a	
"	"	"	10	23±1	Growth	2nd instar	-	2.2	NOEC: <2.6 LOEC: 2.6	b	
Chironomus dilutus	Midge (Insect)	Chir.	10	23±1	Survival	2nd instar	-	5.5	6.24	a	
"	"	"	10	23±1	Survival	2nd instar	-	2.2	7.68	b	
Leptocheirus plumulosus	Amphipod	Aor.	28	24-27	Survival	Neonates	3.75 (2.7-4.8)	4.1	-	c	LR, 1
"	"	"	28	24-27	Survival	Neonates	-	4.1	1.5	c	LR, 1
Leptocheirus plumulosus	Amphipod	Aor.	28	24-27	Growth	Neonates	4.2 (2.9-4.8)	4.1	-	c	LR, 1
"	"	"	28	24-27	Growth	Neonates	-	4.1	1.5	c	LR, 1
Hyalella azteca	Amphipod	Hyal.	10	23	Survival	6-10 d	1.75 (1.53-2.06)	1.4	-	d	LL, 2
"	"	"	10	23	Survival	6-10 d	1.58 (1.34-1.89)	1.1	-	d	LL, 2
"	"	"	10	23	Survival	6-10 d	1.27 (1.05-1.57)	6.5	Survival	d	LL, 2
"	"	"	10	23	Survival	6-10 d	-	2.1	0.23	e	
Hyalella azteca	Amphipod	Hyal.	10	23	Growth	6-10 d	-	1.4	0.382	d	LL, 2
"	"	"	10	23	Growth	6-10 d	-	6.5	0.382	d	LL, 2

Aor. = Aoridae, EC_{50} = exposure concentration that causes effect in 50% of a test population, Excl. = reason for exclusion, Hyal. = Hyalellidae, LC_{50} = exposure concentration lethal to 50% of a test population, OC = organic carbon, Ref = reference.
[a]Putt 2005a, [b]Picard 2010a, [c]Putt 2005b, [d]Amweg et al. 2005, [e]Picard 2010b
[1]Saltwater
[2]Toxicity values based on nominal instead of measured concentrations
[3]Low reliability score

Table 11 Threatened, endangered, or rare species predicted values by Web-ICE.

Surrogate		**Predicted**	
Species	**LC_{50} (µg/L)**	**Species**	**LC_{50} (µg/L)**
Rainbow trout (*Oncorhynchus mykiss)*	0.26	Chinook salmon *(O. tshawytscha)*	0.397 (0.250-0.629)
		Coho salmon (*O. kisutch)*	0.266 (0.173-0.410)
		Lahontan cutthroat trout (*O. clarki henshawi)*	0.397 (0.250-0.629)
		Paiute cutthroat trout (*O. c. seleniris)*	0.397 (0.250-0.629)
		Greenback cutthroat trout (*O. c. stomias*)	0.397 (0.250-0.629)
		Gila trout (*O. gilae*)	0.397 (0.250-0.629)
		Chum salmon (*O. keta*)	0.397 (0.250-0.629)
		Sockeye salmon (*O. nerka*)	0.397 (0.250-0.629)
		Little Kern golden trout (*O. aguabonita whitei*)	0.397 (0.250-0.629)

Appendix A – Aqueous Toxicity Data Summaries

Appendix A1 – Aqueous Toxicity Studies Rated RR

Water Toxicity Data Summary

Baetis spp.

Palmquist KR, Jenkins JJ, Jepson PC (2008b) Clutch morphology and the timing of exposure impact the susceptibility of aquatic insect eggs to esfenvalerate. Environ Toxicol Chem 27:1713-1720

Relevance	Reliability
Score: 90	Score: 73.5
Rating: R	Rating: R

Relevance points taken off for: Standard method (10)

***Baetis* spp.**	**Palmquist et al. 2008b**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Insecta	
Order	Ephemeroptera	
Family	Baetidae	
Genus	*Baetis*	
Species	Spp.	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Test 1: Early-stage eggs Test 2: Late-term eggs (<5-d preceding hatch)	
Source of organisms	Field collected from 3 pristine sites	Rock Creek, Soap Creek (Corvallis, OR) and Metolius Creek (Camp Sherman, OR)
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes Clutches divided into 4 portions of 200-300 eggs & and distributed among test vessels	

***Baetis* spp.**	**Palmquist et al. 2008b**	
Parameter	**Value**	**Comment**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	
Effect 1	Early stage eggs Hatching success (egg mortality)	
Control response 1	97% (3%)	
Effect 2	Late-term eggs Post-hatch survival	
Control response 2	95%	
Temperature	11 $\pm$ 2 ^{o}C	
Test type	Static	
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	Well water	
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported	**Doc./Accept. points**
Feeding	None during exposure	
Purity of test substance	Analytical grade (purchased from ChemService)	
Concentrations measured?	Yes	
Measured is what % of nominal?	60.5-104%	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC/MS	
Concentration of carrier (if any) in test solutions	Not reported	**Accept. points**
Concentration 1 Nom; Meas (µg/L)	Test 2: 0.025; 0.02	10 reps, 200-300 eggs/rep

***Baetis* spp.**	**Palmquist et al. 2008b**	
Parameter	**Value**	**Comment**
Concentration 2 Nom; Meas (µg/L)	Test 2: 0.05; 0.034	10 reps, 200-300 eggs/rep
Concentration 1 Nom; Meas (µg/L)	Test 1: 0.07; 0.0658	10 reps, 200-300 eggs/rep
Concentration 2 Nom; Meas (µg/L)	Test 1: 0.2; 0.208	10 reps, 200-300 eggs/rep
Concentration 3 Nom; Meas (µg/L)	Test 1: 0.5; 0.3025	10 reps, 200-300 eggs/rep
Control	Solvent and negative	10 reps, 200-300 eggs/rep
EC_{50} (95% CI) (µg/L)	Test 1 (early stage eggs) Egg mortality: 0.169 (nominal)	Method: not reported
NOEC	Test 1 (early stage eggs) Hatching success: < 0.0658 Test 2 (late-term eggs) Post-hatch survival: < 0.02	Method: ANOVA p: 0.05 MSD: not reported **Doc./Accept. points**
LOEC	Test 1 (early stage eggs) Hatching success: 0.0658 Test 2 (late-term eggs) Post-hatch survival: 0.02	Same as above
MATC (GeoMean NOEC,LOEC)	Not calculable	
% control at NOEC	Not calculable	**Accept. points**
% control at LOEC	Test 1 (early stage eggs) Hatching success: 83/97*100=86% Test 2 (late-term eggs) Post-hatch survival: 75/95*100=79%	

Notes:

Reliability points taken off for:
Documentation: Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Photoperiod (3), Minimum significant difference (2). Total: 100-18=82

Acceptability: Standard method (5), Measured concentrations within 20% nominal (4), Carrier solvent (4), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Temperature variation (3), Conductivity (1), pH (2), Photoperiod (2), Random design (2), Minimum significant difference (1), % control at NOEC (1). Total: 100-35=65

Reliability score: mean(82, 65)=73.5

Water Toxicity Data Summary

Ceriodaphnia dubia

Brander, SM, Mosser, CM, Geist , J, Hladik, ML, Werner, I. (2012) Esfenvalerate toxicity to the cladoceran *Ceriodaphnia dubia* in the presence of green algae, *Pseudokirchneriella subcapitata*. Ecotoxicology 21:2409–2418

Relevance	Reliability
Score: 92.5	Score: 78.5
Rating: R	Rating: R

Relevance points taken off for: Control description not reported (7.5)

Note: It is unclear (but assumed) from the writing if the experiment which gives the 24h LC50 results follows the same parameters laid out for the experiments with the algae.

C. dubia	**Brander et al. 2012**	
Parameter	**Values**	**Comments**
Test method cited	US EPA WET C. dubia 24 h static non-renewal test procedure	USEPA 2002
Phylum/subphylum	Arthropoda	
Class	Banchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Ceriodaphnia*	
Species	*dubia*	
Family native to N. America?	Yes	
Age/size at start of test/growth phase	24 h	
Source of organisms	In-house lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not stated	**Accept. points**
Test vessels randomized?	Not stated	**Accept. points**
Test duration	24 h	

C. dubia	**Brander et al. 2012**	
Parameter	**Values**	**Comments**
Effect 1	Survival	
Control response 1	>90% survival	
Temperature	20 ± 1 ^{o}C	
Test type	Static non-renewal	
Photoperiod/light intensity	16:8	
Dilution water	De-ionized water	Adjusted to EPA specs
pH	7.7 to 8.1	
Hardness	90–100 mg/L CaCO3	
Alkalinity	50–70 mg/L	
Conductivity	174 to 235 lS/cm, control: 330–360 lS/cm	
Dissolved Oxygen	8.0 to 9.8 mg/L	
Feeding	fed a mixture of the green algae *Pseudokirchneriella subcapitata* and YCT (yeast, cereal leaves, and trout chow) two hours before tests were initiated	
Purity of test substance	99.5 %	
Concentrations measured?	No	**Doc. points**
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Not applicable	**Doc. points**
Concentration of carrier (if any) in test solutions	0.5% total volume of methanol	
Concentration 1 Nom (µg/L)	0.25	Replicates and #/rep not reported **Accept. points**
Concentration 2 Nom (µg/L)	0.5	
Concentration 3 Nom (µg/L)	0.75	
Concentration 4 Nom (µg/L)	1	
Concentration 5 Nom (µg/L)	1.5	
Concentration 6 Nom (µg/L)	2	

C. dubia	**Brander et al. 2012**	
Parameter	**Values**	**Comments**
Concentration 7 Nom (μg/L)	3	
Concentration 8 Nom (μg/L)	6	
Control	Type not reported	**Doc./Accept. points**
LC_{50}	2.4 μg/L	Method: logistic regression

Notes:

Reliability points taken off for:
Documentation: Control type (8), Analytical method (4), Measured concentrations (3), Hypothesis tests (8). Total: 100-23=77
Acceptability: Appropriate control (6), Measured concentrations within 20% nominal (4), Organisms randomized (1), Adequate organisms per rep (2), Random design (2), Adequate replication (2), Hypothesis tests (3). Total: 100-20=80
Reliability score: mean(77, 80)=78.5

Water Toxicity Data Summary

Ceriodaphnia dubia

Yang W, Spurlock F, Liu W, Gan J (2006) Inhibition of aquatic toxicity of pyrethroid insecticides by suspended sediment. Environ Toxicol Chem 25:1913-1919.

Relevance	Reliability
Score: 92.5	Score: 74
Rating: R	Rating: R

Relevance points taken off for: Controls not described (7.5)

C. dubia	**Yang et al. 2006**	
Parameter	**Value**	**Comment**
Test method cited	EPA 1994	
Phylum/subphylum	Arthropoda: Crustacea	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Ceriodaphnia*	
Species	*dubia*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Effect 1	Survival	
Control response 1	>90%	
Temperature	21 $\pm$ 1 ^{o}C	
Test type	Static	
Photoperiod/light intensity	16 h light: 8 h dark	
Dilution water	EPA moderately hard water	
pH	Not reported, but met EPA	**Doc. points**

C. dubia	**Yang et al. 2006**	
Parameter	**Value**	**Comment**
	guidelines	
Hardness	Not reported, but met EPA guidelines	**Doc. points**
Alkalinity	Not reported, but met EPA guidelines	**Doc. points**
Conductivity	Not reported, but met EPA guidelines	**Doc. points**
Dissolved Oxygen	Not reported, but met EPA guidelines	**Doc. points**
Feeding	None during test	
Purity of test substance	98%	
Concentrations measured?	Yes	
Measured is what % of nominal?	73%	
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	acetone	
Concentration 1 Nom (μg/L)	0.01	4 reps, 5/rep
Concentration 2 Nom (μg/L)	0.02	4 reps, 5/rep
Concentration 3 Nom (μg/L)	0.05	4 reps, 5/rep
Concentration 4 Nom (μg/L)	0.1	4 reps, 5/rep
Concentration 5 Nom (μg/L)	0.2	4 reps, 5/rep
Concentration 6 Nom (μg/L)	0.4	4 reps, 5/rep
Control	Not described	4 reps, 5/rep
LC_{50} (95% CI) (μg/L)	0.058 (0.050-0.067)	Method: test determined by ToxCalc (linear regression, linear interpolation, or trimmed spearman-karber)
LC_{50} (95% CI) (μg/L)	**With suspended solids** 25 mg/L 0.049 0.039 (0.011-0.076)	Method: test determined by ToxCalc (linear regression, linear

C. dubia	**Yang et al. 2006**	
Parameter	**Value**	**Comment**
	0.112 (0.072-0.153) 0.088 (0.052-0.129) 50 mg/L 0.092 (0.067-0.126) 0.106 (0.060-0.155)* 0.105 (0.066-0.154) 0.167 (0.110-0.258)* 100 mg/L 0.144 (0.082-0.218)* 0.145 (0.099-0.240)* 0.213 (0.118-0.354)* 0.187 (0.133-0.296)* 200 mg/L 0.302 (0.202-0.439)* 0.349 (0.246-0.503)* 0.363 (0.252-0.523)* 0.270 (0.212-0.350)*	interpolation, or trimmed spearman-karber) *indicates significantly different ($p<0.05$) from sediment-free LC_{50}

Notes:

Reliability points taken off for:
Documentation: Control type (8), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Hypothesis tests (8). Total: 100-32=68

Acceptability: Appropriate control (6), Measured concentrations within 20% nominal (4), Carrier solvent (4), Organisms randomized (1), Random design (2), Hypothesis tests (3). Total: 100-20=80

Reliability score: mean(68, 80)=74

Water Toxicity Data Summary

Daphnia magna

Baer KN (1992a) Static-renewal, acute, 48-hour EC50 of DPX-YB656-58 (Technical Asana) to *Daphnia magna*. Performed by E.I. du Pont de Nemours and Company, Haskell Laboratory for Toxicology and Industrial Medicine, Newark, DE, lab ID: HLR 490-92. DPR ID 123410.

Relevance	Reliability
Score: 100	Score: 94.5
Rating: R	Rating: R

D. magna	**Baer 1992a**	
Parameter	**Value**	**Comment**
Test method cited	USEPA-540/9-85-005	
Phylum/subphylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	magna	
Native to	North America	
Age/size at start of test/growth phase	Neonates (< 24 hrs old)	
Source of organisms	Haskell Laboratory culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	
Test duration	48 h	
Data for multiple times?	Yes	24, 48 h
Acute effect 1	Immobility	Inability to swim 2 body lengths within 15 sec after gentle prodding
Acute control response 1	0%	
Temperature	19.6-19.9 ^{o}C	
Test type	Static renewal	Renewed at 24h

D. magna	**Baer 1992a**	
Parameter	**Value**	**Comment**
Photoperiod/light intensity	16h light (183-258 lux)	8h dark, including 30 min transitional (3.2-6.5 lux)
Dilution water	Haskell Lab well water	
pH	7.3-7.4	
Hardness	78 mg/L	
Alkalinity	84 mg/L	
Conductivity	160 umhos/cm	
Dissolved Oxygen	8.7-8.8 mg/L	
Feeding	None	
Purity of test substance	82.8% esfenvalerate	98.6% total fenvalerate isomers
Concentrations measured? (ug/L)	Yes	
Measured is what % of nominal?	81 – 101%	
Toxicity Values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	$\leq$ 0.18 mL/L	
Concentration 1 Nom/Meas (μg/L)	0.047/0.044	2 reps, 10/rep
Concentration 2 Nom/Meas (μg/L)	0.078/0.079	2 reps, 10/rep
Concentration 3 Nom/Meas (μg/L)	0.13/0.11	2 reps, 10/rep
Concentration 4 Nom/Meas (μg/L)	0.22/0.21	2 reps, 10/rep
Concentration 5 Nom/Meas (μg/L)	0.36/0.32	2 reps, 10/rep
Concentration 6 Nom/Meas (μg/L)	0.60/0.52	2 reps, 10/rep
Concentration 7 Nom/Meas (μg/L)	1.0/0.81	2 reps, 10/rep
Control	Solvent and Negative	2 reps, 10/rep
EC_{50} (95% fiducial interval)	48 h: 0.24 (0.19 – 0.30) μg/L	Method: Probit
NOEC	0.044 μg/L	Method: NR **Doc. points**
LOEC	0.079 μg/L	Not based on statistics
MATC (GeoMean NOEC,LOEC)	Not appropriate to calculate because no statistical test was performed	
% control at NOEC	100% (no immobility	

D. magna	**Baer 1992a**	
Parameter	**Value**	**Comment**
	observed in control or at NOEC)	
% control at LOEC	85%/100%=85%	

Notes:

Method Cited:

2. Zucker, E. 1985. Standard Evaluation Procedure Acute Toxicity Test for Freshwater Invertebrates. EPA-540/9-85-005. U. S. Environmental Protection Agency Office of Pesticide Programs.

Reliability points taken off for:

Documentation: Statistical Significance (2), Significance Level (2), Minimum significant difference (MSD)(2). Total: 100-6=94

Acceptability: Random design (2), Adequate replication (2), MSD (1). Total: 100-5=95

Reliablity score: mean(94,95)=94.5

Water Toxicity Data Summary

Daphnia magna

Hutton DG (1987a) Revised. *Daphnia magna* static acute 48-hour EC50 of technical Asana® insecticide. Performed by E.I. du Pont de Nemours and Company, Inc. Haskell Laboratory for Toxicology and Industrial Medicine, Newark, DE, lab report ID: 402-87, MR 4581-474. EPA MRID: 404440-02.

Relevance	Reliability
Score: 100	Score: 85.5
Rating: R	Rating: R

D. magna	**Hutton 1987a**	
Parameter	**Value**	**Comment**
Test method cited	USEPA 1985	
Phylum/subphylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	magna	
Native to	North America	
Age/size at start of test/growth phase	Neonates (< 24 hrs old)	
Source of organisms	Haskell Laboratory culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	
Data for multiple times?	Yes	24, 48 h
Acute effect 1	Immobility	
Acute control response 1	0%	
Temperature	19.8-20.2 ^{o}C	
Test type	Static	**Accept. points**
Photoperiod/light intensity	16h light/8h dark	
Dilution water	Hard reconstituted water	

D. magna	**Hutton 1987a**	
Parameter	**Value**	**Comment**
pH	8.2-8.3	
Hardness	177 mg/L as $CaCO_3$	
Alkalinity	114 mg/L as $CaCO_3$	
Conductivity	560 umhos/cm	
Dissolved Oxygen	8.3-8.4 mg/L	
Feeding	None	
Purity of test substance	98.6%	
Concentrations measured? (ug/L)	No	
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	No	**Doc. points**
Concentration of carrier (if any) in test solutions	0.06 mL/L acetone	
Concentration 1 Nom (µg/L)	4.0	2 reps, 10/rep Meas. conc. NR **Doc. points**
Concentration 2 Nom (µg/L)	2.4	2 reps, 10/rep
Concentration 3 Nom (µg/L)	1.44	2 reps, 10/rep
Concentration 4 Nom (µg/L)	0.86	2 reps, 10/rep
Concentration 5 Nom (µg/L)	0.52	2 reps, 10/rep
Concentration 6 Nom (µg/L)	0.31	2 reps, 10/rep
Concentration 7 Nom (µg/L)	0.19	2 reps, 10/rep
Concentration 8 Nom (µg/L)	0.11	2 reps, 10/rep
Control	Solvent and negative	2 reps, 10/rep
EC_{50} (95% CI)	24 h: 3.7 (2.7-7.1) µg/L 48 h: 0.90 (0.70-1.16) µg/L	Method: Probit

Notes:
Method cited:

1. Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms, 3d Edition, EPA/600/4-85/013, United States EPA, Cincinnati, Ohio, pp 22-23, 1985.

Reliability points taken off test for:
Documentation: Analytical method (4), Measured Concentrations (3), Hypothesis Tests (8).
Total: 100-15=85

Acceptability: Measured concentrations within 20% Nom (4), Organisms randomly assigned to test containers (1), Exposure type (2), Random design (2), Adequate replication (2), Hypothesis Tests (3). Total: 100-14=86

Reliability score: mean (85,86)=85.5

Water Toxicity Data Summary

Daphnia magna

Hutton DG (1987b) Chronic toxicity of technical Asana® insecticide to *Daphnia magna*. Performed by E.I. du Pont de Nemours and Company, Inc. Haskell Laboratory for Toxicology and Industrial Medicine, Newark, DE, lab report ID: 589-87, MR 4581-474. EPA MRID: 404440-01.

Relevance	Reliability
Score: 90	Score: 85
Rating: R	Rating: R

Relevance points taken off for: Acceptable standard method (10).

D. magna	**Hutton 1987b**	
Parameter	**Value**	**Comment**
Test method cited	Environmental Biology Section Aquatic SOP-T07	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	magna	
Native to	North America	
Age/size at start of test/growth phase	Neonates (< 24 hrs old)	
Source of organisms	Haskell Laboratory	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	21 d	
Data for multiple times?	Yes, water samples	0, 7, 14, 21d
Effect 1	Survival	
Control response 1	100% for water control	93% for acetone control

D. magna	**Hutton 1987b**	
Parameter	**Value**	**Comment**
Effect 2	Reproduction (total young produced)	
Control response 2	6.9-11.0 young per day for water control	4.0-9.7 young/day for acetone control
Effect 3	Reproduction (young/day)	
Control response 3		
Effect 3	Growth	
Control response 3	3.8-4.5mm for water control	3.7-4.1mm for acetone control
Temperature	20 ± 1 ^{o}C	
Test type	Static renewal	Renewed 3 x per week
Photoperiod/light intensity	16h light/8h dark	
Dilution water	Hard reconstituted water	
pH	8.4-8.7	
Hardness	179 mg/L	
Alkalinity	112 mg/L	
Conductivity	547 umhos/cm	
Dissolved Oxygen	8.0-8.2 mg/L	
Feeding	3 x per week	Transferred to fresh test solution w/food 3 x per week
Purity of test substance	98.6%	
Concentrations measured? (ug/L)	Yes	
Measured is what % of nominal?	60 – 120% (84% average)	
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes	GC-ECD
Concentration of carrier (if any) in test solutions	0.1 mL/L acetone	**Accept. points**
Concentration 1 Nom/Meas (µg/L)	0.03/0.025	Survival: 3 reps, 5/rep Growth: 7 reps, 1/rep
Concentration 2 Nom/Meas (µg/L)	0.06/0.052	Survival: 3 reps, 5/rep

D. magna	**Hutton 1987b**	
Parameter	**Value**	**Comment**
		Growth: 7 reps, 1/rep
Concentration 3 Nom/Meas (µg/L)	0.12/0.079	Survival: 3 reps, 5/rep Growth: 7 reps, 1/rep
Concentration 4 Nom/Meas (µg/L)	0.25/0.15	Survival: 3 reps, 5/rep Growth: 7 reps, 1/rep
Concentration 5 Nom/Meas (µg/L)	0.50/0.45	Survival: 3 reps, 5/rep Growth: 7 reps, 1/rep
Concentration 6 Nom/Meas (µg/L)	1.00/1.2	Survival: 3 reps, 5/rep Growth: 7 reps, 1/rep
Control	Solvent and negative	Survival: 3 reps, 5/rep Growth: 7 reps, 1/rep
NOEC (µg/L)	Survival: 0.079 Repro (# of young): 0.052 Repro (young/day): 0.052 Growth (length): 0.052	Method: Dunnett's test Alpha: 0.05 MSD: NR **Doc./Accept. points**
LOEC (µg/L)	Survival: 0.15 Repro (# of young): 0.079 Repro (young/day): 0.079 Growth (length): 0.079	
MATC (GeoMean NOEC, LOEC) (µg/L)	Survival: 0.11 Repro (# of young): 0.064 Repro (young/day): 0.064 Growth (length): 0.064	
% control at NOEC	Survival: 87/93*100=94% Repro (# of young):	

D. magna	**Hutton 1987b**	
Parameter	**Value**	**Comment**
	77.6/75.6*100=103% Repro (young/day): 7.7/7.7*100=100% Growth (length): 3.9/3.9*100=100%	
% control at LOEC	Survival: 60/93*100=65% Repro (# of young): 36.6/75.6*100=48% Repro (young/day): 3.6/7.7*100=47% Growth (length): 3.3/3.9*100=85%	

Notes:
Reliability points taken off for:
Documentation: Minimum significant difference (2), Point estimates (8). Total: 100-10=90
Acceptability: Standard method (5), Measured concentrations within 20% Nom (4), Carrier solvent (4), Organisms randomly assigned (1), Random design (2), Minimum significant difference (1), Point estimates (3). Total: 100-20=80

Reliability score: mean(90, 80)=85

Water Toxicity Data Summary

Gammarus pulex

Cold A, Forbes VE (2004) Consequences of a short pulse of pesticide exposure for survival and reproduction of *Gammarus pulex.* Aquatic Toxicol 67:287-299

Relevance	Reliability
Score: 90	Score: 74
Rating: R	Rating: R

Relevance points taken off for: Standard method (10)

G. pulex	**Cold & Forbes 2004**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Malacostraca	
Order	Amphipoda	
Family	Gammaridae	
Genus	*Gammarus*	
Species	*pulex*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Test 1: large adults (10-14 mm body length) Test 2: small adults (7-8 mm body length)	
Source of organisms	Wild collected – small stream in Denmark	
Have organisms been exposed to contaminants?	Possibly	**Accept. points**
Animals acclimated and disease-free?	Yes, acclimated 14-d & examined for parasites or signs of disease	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Data for multiple times?	24 h, 48 h	
Effect 1	Survival	
Control response 1	100%	

G. pulex	**Cold & Forbes 2004**	
Parameter	**Value**	**Comment**
Temperature	13^{o}C	
Test type	Static	
Photoperiod/light intensity	12 h light: 12 h dark	
Dilution water	OECD artificial water	Followed guideline 202
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported, but chambers were aerated	**Doc. points**
Feeding	Fed daily with leaf discs	**Accept. points**
Purity of test substance	99.9%	
Concentrations measured?	Yes	
Measured is what % of nominal?	Not reported	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	Max: 300 µL/L acetone	
Concentration 1 Nom (µg/L)	0.01	3 reps, 10/rep Meas. conc. NR **Doc. points**
Concentration 2 Nom (µg/L)	0.05	3 reps, 10/rep
Concentration 3 Nom (µg/L)	0.1	3 reps, 10/rep
Concentration 4 Nom (µg/L)	0.5	3 reps, 10/rep
Concentration 5 Nom (µg/L)	1.0	3 reps, 10/rep
Concentration 6 Nom (µg/L)	2.0	3 reps, 10/rep
Control	Solvent	3 reps, 10/rep
LC_{50} (95% CI) (µg/L)	Small 24 h: 0.236 (0.216-0.259) 48 h: 0.137 (0.127-0.151)	Method: logistic regression

G. pulex	**Cold & Forbes 2004**	
Parameter	**Value**	**Comment**
	96 h: 0.138 (0.128-0.151) Large 24 h: 0.340 (0.308-0.376) 48 h: 0.142 (0.131-0.155) 96 h: 0.132 (0.122-0.145)	

Notes:

Reliability points taken off for:
Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Hypothesis tests (8). Total: 100-24=76

Acceptability: Standard method (5), Measured concentrations within 20% nominal (4), No prior contamination (4), Feeding (3), Hardness (2), Alkalinity (2), Conductivity (1), pH (2), Random design (2), Hypothesis tests (3). Total: 100-28=72

Reliability score: mean (76, 72)=74

Water Toxicity Data Summary

Lepomis macrochirus

Forbis AD, Georgie L, Burgess D (1985a) Static acute toxicity report #33174, acute toxicity of M070616 technical to Bluegill Sunfish (*Lepomis macrochirus*). Performed by: Analytical Bio-Chemistry Laboratories, Inc., Colombia, MS. EPA MRID: 00156850.

Relevance	Reliability
Score: 100	Score: 85
Rating: R	Rating: R

L. macrochirus	**Forbis 1985a**	
Parameter	**Value**	**Comment**
Test method cited	USEPA 1975	EPA-660/3-75-009
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Centrarchidae	
Genus	*Lepomis*	
Species	*macrochirus*	
Native to	North America	
Age/size at start of test/growth phase	Weight = 0.19 ± 0.06 g Length = 25 ± 2.7 mm	Measurements made on control group at termination of test
Source of organisms	Commercial culture, Osage Catfisheries	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	14 d
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Data for multiple times?	Yes	24, 48, 96 h
Effect 1	Survival	
Control response 1	100%	
Temperature	22^{o}C (±1)	
Test type	Static	**Accept. points**

L. macrochirus	**Forbis 1985a**	
Parameter	**Value**	**Comment**
Photoperiod/light intensity	16h light: 8 h dark	
Dilution water	Soft reconstituted water	
pH	7.0-7.6	
Hardness	40-45 mg/L	
Alkalinity	30-35 mg/L	
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	4.4-8.8 mg/L (50-100% saturation)	**Accept. points**
Feeding	None	Fed daily until 48 h prior to testing
Purity of test substance	98.8%	
Concentrations measured?	Yes	
Measured is what % of nominal?	60.7-120%	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	GC-ECD	
Concentration of carrier (if any) in test solutions	0.56 mL/15 L (0.038 mL/L)	acetone
Concentration 1 Nom/Meas (µg/L)	0.056/0.045	10/rep Reps: NR **Accept. points**
Concentration 2 Nom/Meas (µg/L)	0.10/0.12	10 fish per aquaria
Concentration 3 Nom/Meas (µg/L)	0.18/0.19	10 fish per aquaria
Concentration 4 Nom/Meas (µg/L)	0.32/0.45	10 fish per aquaria
Concentration 5 Nom/Meas (µg/L)	0.56/0.34	10 fish per aquaria
Control	Negative and solvent	10 fish per aquaria
LC_{50} (µg/L)	24 h: >0.32	Method:
LC_{50} (95%CI) (µg/L)	48 h: 0.38 (0.29-0.57)	Method: Probit
LC_{50} (95%CI) (µg/L)	96 h: 0.26 (0.20-0.36)	Method: Moving average

Notes:

(1) Committee on Methods for Toxicity Tests with Aquatic Organisms (C. E. Stephan, Chairman). 1975. Methods for Acute Toxicity Tests with Fish, Macroinvertebrates and Amphibians. Environmental Protection Agency, Ecological Research Series EPA-660/3-75-009, April, 1975. 61 p.

Reliability points taken off for:
Documentation: Conductivity (2), Hypothesis tests (8). Total: 100-10=90

Acceptability: Measured concentrations within 20% Nom (4), Exposure type (2), Dissolved oxygen (6), Conductivity (1), Random design (2), Adequate replication (2), Hypothesis tests (3). Total: 100-14=80

Reliability score: mean (90,80)=85

Water Toxicity Data Summary

Lepomis macrochirus

Little EE, dwyer FJ, Fairchild JF, DeLonay AJ, Zajicek JL (1993) Survival of bluegill and their behavioral responses during continuous and pulsed exposures to esfenvalerate, a pyrethroid insecticide. Environ Toxicol Chem 12:871-878

Relevance	Reliability
Score: 90	Score: 79.5
Rating: R	Rating: R

Relevance points taken off for: Standard method (10)

L. macrochirus	**Little et al. 1993**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Centrarchidae	
Genus	*Lepomis*	
Species	*macrochirus*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Juveniles, 1.01±0.34 g, 41±4mm length	
Source of organisms	Lab culture	National Fish Hatchery, Mammoth Springs, AR
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	90 d	
Data for multiple times?	Yes, 30 d, 60 d	
Effect 1	Survival	
Control response 1	30 d: 96.9 ± 6.2%	

L. macrochirus	**Little et al. 1993**	
Parameter	**Value**	**Comment**
	60 d: 93.8 ± 12.5% 90 d: 90.6 ± 18.8%	
Effect 2	Growth (length & weight)	
Control response 2	Length: 60.6 ± 3.6 mm Weight: 3.8 ± 0.6 g	
Effect 3	Tremors per minute	
Control response 3	30 d: 0.02 60 d: 0.07 90 d: 0.02	
Temperature	22 ^{o}C	
Test type	Flow-through	
Photoperiod/light intensity	16 h light: 8 h dark	
Dilution water	Well water	
pH	Not reported	**Doc./Accept. points**
Hardness	283 mg/L $CaCO_3$	
Alkalinity	255 mg/L $CaCO_3$	
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported	**Doc./Accept. points**
Feeding	Ad libitum 3 times/day	Salmon starter diet
Purity of test substance	84%	
Concentrations measured?	Yes	
Measured is what % of nominal?	86-112%	
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC	
Concentration of carrier (if any) in test solutions	200 μL/L acetone	
Concentration 1 Nom; Meas (μg/L)	0.01; 0.01 ± 0.008	4 reps, 8/rep
Concentration 2 Nom; Meas (μg/L)	0.025; 0.028 ± 0.01	4 reps, 8/rep
Concentration 3 Nom; Meas (μg/L)	0.050; 0.052 ± 0.01	4 reps, 8/rep
Concentration 4 Nom; Meas (μg/L)	0.100; 0.092 ± 0.02	4 reps, 8/rep
Concentration 5 Nom; Meas (μg/L)	0.200; 0.172 ± 0.05	4 reps, 8/rep
Control	Solvent	4 reps, 8/rep

L. macrochirus	**Little et al. 1993**	
Parameter	**Value**	**Comment**
NOEC	<u>Survival</u> 30 d: 0.092 60 d: 0.052 90 d: 0.052 <u>Tremors</u> 30 d: 0.052 60 d: 0.01 90 d: 0.028	Method: ANOVA, least-significant-difference means comparison p: 0.05 MSD: not reported **Doc./Accept. points**
LOEC	<u>Survival</u> 30 d: 0.172 60 d: 0.092 90 d: 0.092 <u>Tremors</u> 30 d: 0.092 60 d: 0.028 90 d: 0.052	Same as above
MATC (GeoMean NOEC,LOEC)	<u>Survival</u> 30 d: 0.13 60 d: 0.069 90 d: 0.069 <u>Tremors</u> 30 d: 0.069 60 d: 0.017 90 d: 0.038	
% control at NOEC	<u>Survival</u> 30 d: 66.7/96.9*100=69% 60 d: 87.5/93.8*100=93% 90 d: 50.0/90.6*100=55% <u>Tremors</u> 30 d: 0.10/0.02*100=500% 60 d: 0.17/0.07*100=243% 90 d: 0.17/0.02*100=850%	**Accept. points**
% control at LOEC	<u>Survival</u> 30 d: 0/96.9*100=0% 60 d: 0/93.8*100=0% 90 d: 0/90.6*100=0% <u>Tremors</u> 30 d:	

L. macrochirus	**Little et al. 1993**	
Parameter	**Value**	**Comment**
	0.93/0.02*100=46500% 60 d: 0.33/0.07*100=471% 90 d: 0.68/0.02*100=3400%	

Notes:

Reliability points taken off for:
Documentation: Dissolved oxygen (4), Conductivity (2), pH (3), Minimum significant difference (2), Point estimates (8). Total: 100-19=81

Acceptability: Standard method (5), Organisms randomized (1), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Minimum significant difference (1), % control at NOEC (1), Point estimates (3). Total: 100-22=78

Reliability score: mean(81, 78)=79.5

Water Toxicity Data Summary

Morone saxatilis

Geist J, Werner I, Eder KJ, Leutenegger CM 2007) Comparisons of tissue-specific transcription of stress response genes with whole animal endpoints of adverse effect in striped bass (*Morone saxatilis*) following treatment with copper and esfenvalerate. Aquatic Toxicol 85:28-39.

Relevance	Reliability
Score: 90	Score: 79.5
Rating: R	Rating: R

Relevance points taken off for: Standard method (10)

M. saxatilis	**Geist et al. 2007**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Moronidae	
Genus	*Morone*	
Species	*saxatilis*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Juveniles, 81-d old (fork lengths 5.3-8.0 cm)	
Source of organisms	UC Davis lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	24 h	**Accept. points**
Data for multiple times?	Yes, 4 h	
Effect 1	Survival	
Control response 1	100%	
Effect 2	Normal swimming behavior	
Control response 2	96%	
Temperature	20.3 $\pm$ 0.4 ^{o}C	

M. saxatilis	**Geist et al. 2007**	
Parameter	**Value**	**Comment**
Test type	Static	**Accept. points**
Photoperiod/light intensity	16 h light: 8 h dark	
Dilution water	Filtered well water	
pH	7.8	
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	8.2 mg/L	
Feeding	None during test	
Purity of test substance	98%	
Concentrations measured?	Yes	
Measured is what % of nominal?	63-73%	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	No	**Doc. points**
Concentration of carrier (if any) in test solutions	200 μL/L methanol	
Concentration 1 Nom; Meas (μg/L)	1; 0.64	5 reps, 5/rep # of conc. **Accept. points**
Concentration 2 Nom; Meas (μg/L)	3; 2.20	5 reps, 5/rep
Concentration 3 Nom; Meas (μg/L)	7; 4.40	5 reps, 5/rep
Concentration 4 Nom; Meas (μg/L)	10; 6.50	5 reps, 5/rep
Control	Negative and solvent	5 reps, 5/rep
LC_{50} (95% CI) (μg/L)	24 h: 2.17	Method: linear regression, non-linear regression, or linear interpolation
EC_{25} (95% CI) (μg/L)	<u>Swimming behavior</u> 4 h: 3.88 24 h: 1.07	Method: linear regression, non-linear regression, or linear interpolation
NOEC	<u>Survival</u>	Method: Dunnett's

M. saxatilis	**Geist et al. 2007**	
Parameter	**Value**	**Comment**
	4 h: 6.5 24 h: 0.64 <u>Swimming behavior</u> 4 h: 2.2 24 h: 0.64	Test, the t test with the Bonferroni adjustment, Steel's Many-one Rank Test, or the Wilcoxon Rank Sum Test with the Bonferroni adjustment p <0.05 MSD: not reported **Doc./Accept. points**
LOEC	<u>Survival</u> 4 h: > 6.5 24 h: 2.2 <u>Swimming behavior</u> 4 h: 4.4 24 h: 2.2	Same as above
MATC (GeoMean NOEC,LOEC)	<u>Survival</u> 24 h: 1.2 <u>Swimming behavior</u> 4 h: 3.1 24 h: 1.2	
% control at NOEC	Not reported	**Doc./Accept. points**
% control at LOEC	Not reported	**Doc./Accept. points**

Notes:

Reliability points taken off for:
<u>Documentation:</u> Analytical method (4), Hardness (2), Alkalinity (2), Conductivity (2), Minimum significant difference (2), % control at NOEC/LOEC (2). Total: 100-14=86

<u>Acceptability:</u> Standard method (5), Appropriate duration (2), Measured concentrations within 20% nominal (4), Organisms randomized (1), Exposure type (2), Hardness (2), Alkalinity (2), Conductivity (1), Number of concentrations (3), Random design (2), Minimum significant difference (1), % control at NOEC (1), % control at LOEC (1). Total: 100-27=73

Reliability score: mean(86, 73)=79.5

Water Toxicity Data Summary

Oncorhynchus mykiss

Forbis AD, Georgie L, Burgess D (1985b) Static acute toxicity report #33173, acute toxicity of M070616 technical to Rainbow Trout (*Salmo gairdneri*). Performed by Analytical Bio-Chemistry Laboratories, Inc., Colombia, MS.

Relevance	Reliability
Score: 100	Score: 89.5
Rating: R	Rating: R

O. mykiss	**Forbis et al. 1985b**	
Parameter	**Value**	**Comment**
Test method cited	USEPA 1975	EPA-660/3-75-009
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	*mykiss*	
Native to	North America	
Age/size at start of test/growth phase	Weight: 0.56 ± 0.17 g Length: 41 ± 3.3 mm	Measurements made on control group at termination of test
Source of organisms	Commercial culture	Trout Lodge, McMillin, WA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	14 d
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Data for multiple times?	Yes	24, 48, 96 h
Effect 1	Survival	
Control response 1	100%	
Temperature	11^{o}C (±1)	
Test type	Static	**Accept. points**

O. mykiss	**Forbis et al. 1985b**	
Parameter	**Value**	**Comment**
Photoperiod/light intensity	16 h light: 8 h dark	
Dilution water	Soft reconstituted well water	
pH	7.1-7.7	
Hardness	40-45 mg/L $CaCO_3$	
Alkalinity	30-35 mg/L $CaCO_3$	
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	7.7-8.7 mg/L	
Feeding	None	Fed daily until 48 h prior to testing
Purity of test substance	98.8%	
Concentrations measured?	Yes	
Measured is what % of nominal?	46.4-87.5%	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	GC-ECD	
Concentration of carrier (if any) in test solutions	0.32 mL/15 L (0.021 mL/L)	acetone
Concentration 1 Nom/Meas (µg/L)	0.032/0.028	10/rep # of reps: **Accept. points**
Concentration 2 Nom/Meas (µg/L)	0.056/0.026	10/rep
Concentration 3 Nom/Meas (µg/L)	0.10/0.051	10/rep
Concentration 4 Nom/Meas (µg/L)	0.18/0.091	10/rep
Concentration 5 Nom/Meas (µg/L)	0.32/0.017	10/rep
Control	Negative and solvent	10/rep
LC_{50} (95% CI) (µg/L)	24 h: > 0.32 48 h: > 0.18 96 h: 0.26 (0.20-0.38)	Method: probit
NOEC (µg/L)	96 h: 0.10	Method: Not reported (not based on statistical test) **Doc. points** p: Not reported

O. mykiss	**Forbis et al. 1985b**	
Parameter	**Value**	**Comment**
		Doc. points MSD: Not reported **Doc./Accept. points**
LOEC; indicate calculation method	No statistical analysis	
MATC (GeoMean NOEC,LOEC)	No statistical analysis	
% control at NOEC	100%/100%=100%	No effect observed in control group
% control at LOEC	Not applicable	**Accept. points**

Notes:

(1) Committee on Methods for Toxicity Tests with Aquatic Organisms (C. E. Stephan, Chairman). 1975. Methods for Acute Toxicity Tests with Fish, Macroinvertebrates and Amphibians. Environmental Protection Agency, Ecological Research Series EPA-660/3-75-009, April, 1975. 61 p.

Reliability points taken off for:
Documentation: Conductivity (2), Statistical Significance (2), Significance Level (2), Minimum significant difference (MSD)(2). Total: 100-8=92

Acceptability: Measured concentrations within 20% Nom (4), Exposure type (2), Conductivity (1), Random design (2), Adequate replication (2), Minimum significant difference (1), % control at LOEC (1). Total: 100-13=87

Reliability score: mean(92, 87)=89.5

Water Toxicity Data Summary

Pimephales promelas

Denton DL, Wheelock CE, Murray SA, Deanovic LA, Hammock BD, Hinton DE (2003) Joint acute toxicity of esfenvalerate and diazinon to larval fathead minnows (*Pimephales promelas*). Environ Toxicol Chem 22:336-341

Relevance	Reliability
Score: 100	Score: 77
Rating: R	Rating: R

P. promelas	**Denton et al. 2003**	
Parameter	**Value**	**Comment**
Test method cited	USEPA 1993	
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Pimephales*	
Species	*promelas*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	7 d	
Source of organisms	Commercial supplier	Aquatox, Hot Springs, AK
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Not reported	**Accept. points**
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Data for multiple times?	Yes, 48 h, 72 h	
Effect 1	Survival	
Control response 1	>90%	
Temperature	20 ^{o}C	**Accept. points**
Test type	Static renewal	
Photoperiod/light intensity	Not reported	**Doc./Accept. points**

P. promelas	**Denton et al. 2003**	
Parameter	**Value**	**Comment**
Dilution water	EPA moderately hard water	
pH	Not reported, but within EPA method guidelines	**Doc. points**
Hardness	Not reported, but within EPA method guidelines	**Doc. points**
Alkalinity	Not reported, but within EPA method guidelines	**Doc. points**
Conductivity	Not reported, but within EPA method guidelines	**Doc. points**
Dissolved Oxygen	Not reported, but within EPA method guidelines	**Doc. points**
Feeding	Yes, 2 h before test and at water renewal	**Accept. points**
Purity of test substance	98.0%	
Concentrations measured?	Yes	**Doc. points**
Measured is what % of nominal?	GC/MS: 50-133% ELISA: 70-90%	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC\MS and ELISA	
Concentration of carrier (if any) in test solutions	< 0.5 mL/L methanol	
Concentration 1 Nom (µg/L)	0.10	3 reps, 10/rep
Concentration 2 Nom (µg/L)	0.15	3 reps, 10/rep
Concentration 3 Nom (µg/L)	0.20	3 reps, 10/rep
Concentration 4 Nom (µg/L)	0.25	3 reps, 10/rep
Concentration 5 Nom (µg/L)	0.30	3 reps, 10/rep
Control	Solvent and negative	3 reps, 10/rep
LC_{50} (95% CI) (µg/L)	<u>96 h</u> Test 1: 0.18 Test 2: 0.22 Test 3: 0.22 <u>72 h</u> 0.26 <u>48 h</u> 0.30	Method: probit

Notes:

Reliability points taken off for:
Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Photoperiod (3), Hypothesis tests (8). Total: 100-27=73

Acceptability: Measured concentrations within 20% nominal (4), Organisms randomized (1), Feeding (3), Acclimation (1), Temperature variation (3), Photoperiod (2), Random design (2), Hypothesis tests (3). Total: 100-19=81
Reliability score: mean(73, 81)=77

Appendix A2 – Aqueous Toxicity Studies rated RL, LR, LL

Water Toxicity Data Summary

Brachycentrus americanus

Johnson KR, Jepson PC, Jenkins JJ (2008) Esfenvalerate-induced case-abandonment in the larvae of the caddisfly (*Brachycentrus americanus*). Environ Toxicol Chem 27:397-403

Relevance	Reliability
Score: 82.5	Score: 62
Rating: L	Rating: L

Relevance points taken off for: Standard method (10), Control description (7.5)

B. americanus	**Johnson et al. 2008**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Insecta	
Order	Trichoptera	
Family	Brachycentridae	
Genus	*Brachycentrus*	
Species	*americanus*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	5^{th} instar (case length ~ 15mm)	
Source of organisms	Field collected from a pristine site in the Metolious River	Camp Sherman, OR
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes, acclimated 36 h	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	
Effect 1	Case abandonment	
Control response 1	0% (100% remaining in case)	
Effect 2	Case rebuilding during 96 h recovery period (organisms	

B. americanus	**Johnson et al. 2008**	
Parameter	**Value**	**Comment**
	placed in clean water & given detritus)	
Control response 2	Unexposed detritus: 80% Exposed detritus: 70%	
Effect 3	Strength of cases built post-exposure (pressure needed to crush the case)	
Control response 3	Unexposed detritus: 160 kPa Exposed detritus: 130 kPa	
Temperature	11 $\pm$ 1 ^{o}C	
Test type	Static	
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	Well water	
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported, but all flasks were aerated during test	**Doc./Accept. points**
Feeding	None during testing	
Purity of test substance	Analytical grade (purchased from ChemService)	
Concentrations measured?	Yes	
Measured is what % of nominal?	65-85%	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Yes, GC/MS	
Concentration of carrier (if any) in test solutions	0.00004 mL/L acetone	
Concentration 1 Nom (μg/L)	Case abandonment: 0.05	5 tests with 5 reps, 10/rep

B. americanus	**Johnson et al. 2008**	
Parameter	**Value**	**Comment**
Concentration 2 Nom (μg/L)	Case abandonment: 0.1	5 tests with 5 reps, 10/rep
Concentration 3 Nom (μg/L)	Case abandonment: 0.2 Case rebuilding: 0.2 Case strength: 0.2	5 tests with 5 reps, 10/rep
Concentration 4 Nom (μg/L)	Case abandonment: 0.4 Case rebuilding: 0.4 Case strength: 0.4	5 tests with 5 reps, 10/rep
Control	All tests Not described, likely a negative control	5 tests with 5 reps, 10/rep
NOEC	Case abandonment: 0.05 Case rebuilding: < 0.2 Case strength: < 0.2	Method: ANOVA p: 0.01 (case aband, case rebuild) p: 0.05 (case strength) MSD: not reported **Doc./Accept. points**
LOEC	Case abandonment: 0.1 Case rebuilding: 0.2 Case strength: 0.2	
MATC (GeoMean NOEC,LOEC)	Case abandonment: 0.07	
% control at NOEC	95/100*100=95%	
% control at LOEC	73/100*100=73%	

Notes:

Reliability points taken off for:
Documentation: Control type (8), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Photoperiod (3), Minimum significant difference (2), Point estimates (8). Total: 100-37=63

Acceptability: Standard method (5), Appropriate control (6), Measured concentrations within 20% nominal (4), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Photoperiod (2), Number of concentrations (3), Random design (2), Minimum significant difference (1), Point estimates (3). Total: 100-39=61
Reliability score: mean(63, 61)=62

Water Toxicity Data Summary

Brachycentrus americanus

Palmquist KR, Jenkins JJ, Jepson PC (2008b) Clutch morphology and the timing of exposure impact the susceptibility of aquatic insect eggs to esfenvalerate. Environ Toxicol Chem 27:1713-1720

Relevance	Reliability
Score: 82.5	Score: 61.5
Rating: L	Rating: L

Relevance points taken off for: Standard method (10), Control description (7.5)

B. americanus	**Palmquist et al. 2008b**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Insecta	
Order	Trichoptera	
Family	Brachycentridae	
Genus	*Brachycentrus*	
Species	*americanus*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Early-stage eggs (intact egg clutch)	
Source of organisms	Field-collected from pristine site	Metolius River, Camp Sherman, OR
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Egg clutches: not/applicable b/c 1 clutch/rep	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	
Effect 1	Hatching success	
Control response 1	98%	
Temperature	$11 \pm 2\ ^{o}C$	
Test type	Static	

B. americanus	**Palmquist et al. 2008b**	
Parameter	**Value**	**Comment**
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	Well water	
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported	**Doc./Accept. points**
Feeding	None during exposure	
Purity of test substance	Analytical grade (purchased from ChemService)	
Concentrations measured?	Yes	
Measured is what % of nominal?	60.5-138%	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC/MS	
Concentration of carrier (if any) in test solutions	Not reported	**Accept. points**
Concentration 1 Nom; Meas (μg/L)	0.07; 0.0658	3 reps, 1 clutch/rep
Concentration 2 Nom; Meas (μg/L)	0.2; 0.208	3 reps, 1 clutch/rep
Concentration 3 Nom; Meas (μg/L)	0.5; 0.3025	3 reps, 1 clutch/rep
Concentration 4 Nom; Meas (μg/L)	1.0; 0.94	3 reps, 1 clutch/rep
Concentration 5 Nom; Meas (μg/L)	2.0; 2.16	3 reps, 1 clutch/rep
Concentration 6 Nom; Meas (μg/L)	4.0; 5.52	3 reps, 1 clutch/rep
Control	Not described	3 reps, 1 clutch/rep **Accept. points**
NOEC	Hatching success (survival): 0.94	Method: ANOVA p: 0.05 MSD: not reported **Doc./Accept. points**

B. americanus	**Palmquist et al. 2008b**	
Parameter	**Value**	**Comment**
LOEC	Hatching success (survival): 2.16	
MATC (GeoMean NOEC,LOEC)	Hatching success (survival): 1.4	
% control at NOEC	97/98*100=99%	
% control at LOEC	75/98*100=77%	

Notes:

Reliability points taken off for:
Documentation: Control type (8), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Photoperiod (3), Minimum significant difference (2), Point estimates (8). Total: 100-34=66

Acceptability: Standard method (5), Appropriate control (6), Measured concentrations within 20% nominal (4), Carrier solvent (4), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Temperature variation (3), Conductivity (1), pH (2), Photoperiod (2), Random design (2), Minimum significant difference (1), Point estimates (3). Total: 100-43=57

Reliability score: mean(66, 57)=61.5

Water Toxicity Data Summary

Chironomus dilutus

Belden JB, Lydy MJ (2006) Joint toxicity of chlorpyrifos and esfenvalerate to fathead minnows and midge larvae. Environ Toxicol Chem 25:623-629.

Relevance	Reliability
Score: 75	Score: 61.5
Rating: L	Rating: L

Relevance points taken off for: Standard method (10), Control not described and response not reported (15 - mobility)

C. dilutus	**Belden & Lydy 2006**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Chironomidae	
Genus	*Chironomus*	
Species	*dilutus*	
Native to	North America	
Age/size at start of test/growth phase	Late 3rd-early 4th instar (14-16 d old)	
Source of organisms	In-house Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Effect 1	Mobility	Ability to perform a figure-eight swimming motion after gentle probing
Control response 1	Mobility: not reported Mortality: <10%	**Accept. points**

C. dilutus	**Belden & Lydy 2006**	
Parameter	**Value**	**Comment**
Temperature	21 $\pm$ 2 ^{o}C	**Accept. points**
Test type	Static	**Accept. points**
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	EPA Moderately hard water	
pH	7.8-8.3	
Hardness	Meas., not reported. Met EPA specifications	**Doc. points**
Alkalinity	Meas., not reported. Met EPA specifications	**Doc. points**
Conductivity	Meas., not reported. Met EPA specifications	**Doc. points**
Dissolved Oxygen	>70% saturation	
Feeding	None reported	
Purity of test substance	98%	
Concentrations measured?	No	
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Not applicable	**Doc. points**
Concentration of carrier (if any) in test solutions	Not reported	**Accept. points**
Concentration 1 Nom /meas (µg/L)	5 concentrations, Conc. not reported **Doc. points**	3 reps, 10/rep
Concentration 2 Nom /meas (µg/L)	"	
Concentration 3 Nom /meas (µg/L)	"	
Concentration 4 Nom /meas (µg/L)	"	
Concentration 5 Nom /meas (µg/L)	"	
Control	Not described	**Doc./Accept. points**
EC_{50} (95% CI) (µg/L)	0.21 (0.16-0.27)	Method: log-probit
EC_{10} (95% CI) (µg/L)	0.078 (0.040-0.111)	Method: log-probit

Notes:

Reliability points taken off for:

Documentation: Control type (8) Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Conductivity (2), Photoperiod (3), Hypothesis tests (8). Total: 100-35=65

Acceptability: Standard method (5), Control description (6), Control response (9), Measured concentration within 20% nominal (4), Carrier solvent (4), Exposure type (2), Temperature variation (3), Photoperiod (2), Random design (2), Dilution factor (2), Hypothesis tests (3). Total: 100- 42=58

Reliability score: mean(65, 58)=61.5

Water Toxicity Data Summary

Cyprinus carpio

Takimoto, Y, Kagoshima, M, Matsuda, T, and Miyamoto, J. (1985) The acute toxicities of S-1844 (esfenvalerate) and S-5602 (fenvalerate) to Carp (*Cyprinus carpio*). Performed by Sumito Laboratory, lab ID: LLM-50-002; submitted to Dupont, Report #: AMR 2192-91. DPR study #: 115831

Relevance	Reliability
Score: 75	Score: 67.5
Rating: L	Rating: L

*Reasons for less than 100 pts for relevance: Acceptable Standard method (10), Chemical purity (15)

C. carpio	**Takimoto et al. 1985**	
Parameter	**Values**	**Comments**
Test method cited	Not stated	**Accept. points**
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Cyprinus*	
Species	*carpio*	
Family native to N. America?	Yes	
Age/size at start of test/growth phase	Juvenile, 0.78 $\pm$ 0.13 g weight, 3.07 $\pm$ 0.20 cm length	
Source of organisms	Lab culture - Nihon Youshoku Co., Japan	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	4 wk accl.
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Data for multiple times?	Yes	24, 48, 72 & 96h
Acute effect 1	Survival	
Acute control response 1	100% for negative and	

C. carpio	**Takimoto et al. 1985**	
Parameter	**Values**	**Comments**
	suspension controls	
Temperature	25 ± 1 ^{o}C	
Test type	Static	**Accept. points**
Photoperiod/light intensity	16:8 Light: dark	
Dilution water	De-chlorinated tap water	
pH	7.7 to 7.8	
Hardness	50–70 mg/L $CaCO_3$	
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported	**Doc./Accept. points**
Feeding	Feeding withheld 48 hr prior to and during tests	
Purity of test substance	94.5% esfenvalerate mixed with 5 times weight of an emulsifier to create a suspension (Tween 80, resulting conc. of 37.5 μg/L)	**Accept. points**
Concentrations measured? (ug/L)	No	
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	No	**Doc. points**
Concentration of carrier (if any) in test solutions	37.5 μg/L Tween 80 suspension, additional solvent not reported	**Accept. points**
Concentration 1 Nom (μg/L)	0.10	1 rep, 10/rep Meas. conc. NR **Doc. points** # of reps **Accept. points**
Concentration 2 Nom (μg/L)	0.32	1 rep, 10/rep
Concentration 3 Nom (μg/L)	0.56	1 rep, 10/rep
Concentration 4 Nom (μg/L)	0.75	1 rep, 10/rep
Concentration 5 Nom (μg/L)	0.87	1 rep, 10/rep
Concentration 6 Nom (μg/L)	1.00	1 rep, 10/rep

C. carpio	**Takimoto et al. 1985**	
Parameter	**Values**	**Comments**
Concentration 7 Nom (μg/L)	1.35	1 rep, 10/rep
Concentration 8 Nom (μg/L)	1.80	1 rep, 10/rep
Concentration 9 Nom (μg/L)	2.40	1 rep, 10/rep
Concentration 10 Nom (μg/L)	3.20	1 rep, 10/rep
Control	Negative and suspension controls (37.5 μg/L suspension)	1 rep, 10/rep
LC_{50} (95% CI)	24 hr: 1.34 (1.12-1.66) μg/L 48 hr: 1.34 (1.12-1.66) μg/L 72 hr: 1.29 (0.99-1.70) μg/L 96 hr: 1.17 (0.83-1.39) μg/L	Method: probit

Notes:

Reliability points taken off for:
Documentation: Analytical method (4), Measured concentrations (3), Alkalinity (2), Conductivity (2), Dissolved Oxygen (4), Hypothesis tests (8). Total: 100-23=77

Acceptability: Acceptable method (5), Chemical purity (10), Measured conc. within 20% nominal (4), Carrier solvent (4), Organisms randomly assigned (1), Exposure type (2), Alkalinity (2), Dissolved Oxygen (6), Conductivity (1), Random design (2), Adequate replication (2), Hypothesis tests (3). Total: 100-42=58

Reliability score: mean (77, 58)=67.5

Water Toxicity Data Summary

Daphnia carinata

Barry MJ, Logan DC, Ahokas JT, Holdway DA (1995) Effect of algal food concentration on toxicity of two agricultural pesticides to *Daphnia carinata.* Ecotoxicol Environ Safe 32:273-279

Relevance
Score: 75
Rating: L

Reliability
Score: 1st reproductive instar 72.5;
2nd reproductive instar 66.5
Rating: L

Relevance points taken off for: Standard method (10), Chemical purity (15)

D. carinata	**Barry et al. 1995**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class		
Order		
Family	Daphniidae	
Genus	*Daphnia*	
Species	*carinata*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Neonates < 24 h	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Yes	
Test duration	6 days	
Data for multiple times?	3 d, > 6 d (time to second brood not reported)	
Effect 1	Survival	
Control response 1	100%	
Effect 2	Carapace length at maturity (1st reproductive instar)	

D. carinata	**Barry et al. 1995**	
Parameter	**Value**	**Comment**
Control response 2	3.3 mm	
Effect 3	# of eggs in first brood	
Control response 3	28	
Effect 4	Carapace length of the 2nd reproductive instar	
Control response 4	4.2 mm	
Effect 5	# of eggs in second brood	
Control response 5	64	
Temperature	$20 \pm 1\ ^{o}C$	
Test type	Static renewal	Renewed every 24 h
Photoperiod/light intensity	16 h light: 8 h dark	
Dilution water	Synthetic pond water	
pH	6.8-7.0	
Hardness	mg/L $CaCO_3$	
Alkalinity	mg/L $CaCO_3$	
Conductivity	umhos/cm	
Dissolved Oxygen	80-100% saturation	
Feeding	Fed *Selenastrum* ad libitum	2×10^5 cells/ml
Purity of test substance		
Concentrations measured?	Yes	
Measured is what % of nominal?	Not reported	
Toxicity values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Yes, GC	
Concentration of carrier (if any) in test solutions	24 uL acetone/L	
Concentration 1 Nom; Meas (μg/L)	5	4 reps, 6/rep
Concentration 2 Nom; Meas (μg/L)	10	4 reps, 6/rep
Concentration 3 Nom; Meas (μg/L)	50	4 reps, 6/rep
Concentration 4 Nom; Meas (μg/L)	100	4 reps, 6/rep
Concentration 5 Nom; Meas (μg/L)	500	4 reps, 6/rep
Control	Solvent	4 reps, 6/rep
NOEC	Survival: 100 (3 & 6 d equivalent) Carapace length at maturity:	Method: ANOVA with Tukey's test p: 0.05

D. carinata	**Barry et al. 1995**	
Parameter	**Value**	**Comment**
	50 # of eggs in first brood: 50 Carapace length of the 2nd reproductive instar: 10 # of eggs in second brood: 10	MSD: not reported
LOEC	Survival: 500 (3 & 6 d equivalent) Carapace length at maturity: 100 # of eggs in first brood: 100 Carapace length of the 2nd reproductive instar: 50 # of eggs in second brood: 50	
MATC (GeoMean NOEC,LOEC)	Survival: 224 Carapace length at maturity: 71 # of eggs in first brood: 71 Carapace length of the 2nd reproductive instar: 22 # of eggs in second brood: 22	
% control at NOEC	Survival: 100/100*100=100% Carapace length at maturity: 3.1/3.3*100=94% # of eggs in first brood: 26/28*100=93% Carapace length of the 2nd reproductive instar: 4.3/4.2*100=102% # of eggs in second brood: 76/64*100=119%	
% control at LOEC	Survival: 0/100*100=0% Carapace length at maturity: 2.6/3.3*100=79% # of eggs in first brood: 8/28*100=29% Carapace length of the 2nd reproductive instar:	

D. carinata	**Barry et al. 1995**	
Parameter	**Value**	**Comment**
	3.4/4.2*100=81% # of eggs in second brood: 12/64*100=19%	

Notes:

Reliability points taken off for:
Documentation: Exposure duration (12 – 2nd reproductive instar endpoints only), Chemical purity (5), Measured concentrations (3), Hardness (2), Alkalinity (2), Conductivity (2), Minimum significant difference (2), Point estimates (8).
1st reproductive instars: Total: 100-24=76
2nd reproductive instars: Total: 100-36=64

Acceptability: Standard method (5), Chemical purity (10), Measured concentrations within 20% nominal (4), Feeding (3), Hardness (2), Alkalinity (2), Conductivity (1), Minimum significant difference (1), Point estimates (3). Total: 100-31=69

Reliability score:
1st reproductive instar: mean(76, 69)=72.5
2nd reproductive instar: mean(64, 69)=66.5

Water Toxicity Data Summary

Daphnia magna

Bjergager M-B A, Hanson ML, Solomon KR, Cedergreen N (2012) Synergy between procloraz and Esfenvalerate in *Daphnia magna* from acute and subchronic exposures in the laboratory and microcosms. Aquatic Toxicol 110-111:17-24

Relevance	Reliability
Score: 100	Score: 62
Rating: R	Rating: L

D. magna	**Bjergager et al. 2012**	
Parameter	**Value**	**Comment**
Test method cited	OECD 2004	
Phylum/subphylum	Arthropoda	
Class		
Order	Branchiopoda	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family native to N. America?	Yes	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	In-house lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	
Effect 1	Mobility	
Control response 1	Test 1: 93% Test 2: 94%	
Temperature	20 ^{o}C	
Test type	Static	
Photoperiod/light intensity	16 h light: 8 h dark	
Dilution water	Not reported	**Doc./Accept. points**

D. magna	**Bjergager et al. 2012**	
Parameter	**Value**	**Comment**
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported	**Doc./Accept. points**
Feeding	Not reported	**Accept. points**
Purity of test substance	99.8%	
Concentrations measured?	No	
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Not applicable	**Doc. points**
Concentration of carrier (if any) in test solutions	<0.1 mL/L acetone	
Concentration 1 Nom; Meas (µg/L	Nom & Meas Conc. Not reported **Doc. points** Number of conc. **Accept. points** Dilution factor **Accept. points**	4 reps, 5/rep
Concentration 2 Nom; Meas (µg/L	"	
Concentration 3 Nom; Meas (µg/L	"	
Concentration 4 Nom; Meas (µg/L	"	
Concentration 5 Nom; Meas (µg/L	"	
Control	Negative **Accept. points (no solvent control)**	8 reps, 5/rep
EC_{50} (std error) (µg/L)	Test 1: 0.16 $\pm$ 0.03 Test 2: 0.05 $\pm$ 0.01	Method:

Notes:

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Dilution water (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Hypothesis tests (8). Total: 100-34=66

Acceptability: Appropriate control (6), Measured conc. Within 20% nominal (4), Organisms randomized (1), Feeding (3), Dilution water (2), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Temperature variation (3), Conductivity (1), pH (2), Number of concentrations (3), Random design (2), Dilution factor (2), Hypothesis tests (3). Total: 100-42=58

Reliability score: mean(66, 58)=62

Water Toxicity Data Summary

Hypomesus transpacificus

Connon RE, Geist J, Pfeiff J, Loguinov AV, D'Abronzo LS, Wintz H, Vulpe CD, Werner I (2009) Linking mechanistic and behavioral responses to sublethal Esfenvalerate exposure in the endangered delta smelt; *Hypomesus transpacificus* (Fam. Osmeridae). BMC Genomics 10:608.

Relevance	Reliability
Score: 75	Score: 79.5
Rating: L	Rating: R

Relevance points taken off for: Standard method (10), Not freshwater (15)

H. transpacificus	**Connon et al. 2009**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Osmeriformes	
Family	Osmeridae	
Genus	*Hypomesus*	
Species	*transpacificus*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Test 1: 10 d larvae (0.5 mg) Test 2: 52 d larvae (2.5 mg)	
Source of organisms	Lab culture	Fish Conservation and Culture Lab, UC Davis
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes, 24 h	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	24 h	**Accept. points**
Data for multiple times?	Yes, 4 h	
Effect 1	Survival	
Control response 1	10-d old: 85% (from fig. 1a) 52-d old: >95% (from fig.	

H. transpacificus	**Connon et al. 2009**	
Parameter	**Value**	**Comment**
	1b)	
Effect 2	Aberrant swimming	
Control response 2	10-d old (4h): <10% (fig. 1a) 10-d old (24h): <30% (fig. 1a) 52-d old (4h): ~30% (fig 1b) 52-d old (24h): ~30% (fig 1b)	
Temperature	17 $\pm$ 1.2 ^{o}C	
Test type	Static	**Accept. points**
Photoperiod/light intensity	16 h light; 8 h dark	
Dilution water	EPA moderately hard water	
pH	7.1-7.5	
Hardness	80-100 mg/L $CaCO_3$	
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported Salinity of 650-900 µS/cm	**Doc./Accept. points**
Dissolved Oxygen	> 6.5 mg/L	
Feeding	None during test	
Purity of test substance	Technical	
Concentrations measured?	No	**Doc. points**
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Not applicable	**Doc. points**
Concentration of carrier (if any) in test solutions	0.2 mL/L methanol	
Concentration 1 Nom; Meas (µg/L)	0.0313	4 reps, 10/rep
Concentration 2 Nom; Meas (µg/L)	0.0625	4 reps, 10/rep
Concentration 3 Nom; Meas (µg/L)	0.125	4 reps, 10/rep
Concentration 4 Nom; Meas (µg/L)	0.250	4 reps, 10/rep
Concentration 5 Nom; Meas (µg/L)	0.500	4 reps, 10/rep
Control	Negative and solvent	4 reps, 10/rep
LC_{50} (95% CI) (µg/L)	10-d old	Method: linear

H. transpacificus	**Connon et al. 2009**	
Parameter	**Value**	**Comment**
	24 h: 0.19 52-d old 24 h: 0.24	regression
EC_{50} (95% CI) (µg/L)	10-d old 4 h: 0.38 24 h: 0.04 52-d old 4 h: 0.13 24 h: 0.11	Method: linear regression

Notes:

Reliability points taken off for:
Documentation: Analytical method (4), Measured concentrations (3), Alkalinity (2), Conductivity (2), Hypothesis tests (8). Total: 100-19=81

Acceptability: Standard method (5), Appropriate duration (2), Measured concentrations within 20% nominal (4), Organisms randomized (1), Exposure type (2), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests (3). Total: 100-22=78

Reliability score: mean(81,78)=79.5

Water Toxicity Data Summary

Oncorhynchus tshawytscha

Viant MR, Pincetich CA, Tjeerdema RS (2006) Metabolic effects of dinoseb, diazinon and esfenvalerate in eyed eggs and alevins of Chinook salmon (*Oncorhynchus tshawytscha*) determined by 1H NMR metabolomics. Aquat Toxicol 77:359-371

Relevance	Reliability
Score: 100	Score: 70
Rating: R	Rating: L

O. tshawytscha	**Viant et al. 2006**	
Parameter	**Value**	**Comment**
Test method cited	EPA 1994	
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	*tshawytscha*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Alevins	
Source of organisms	Spawned from wild caught fall-run Chinook salmon	Nimbus Hatchery, Folsom, CA
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Effect 1	Survival	
Control response 1	100%	
Temperature	$10 \pm 1\ ^{o}C$	
Test type	Static renewal	Renewed every 8 h
Photoperiod/light intensity	Complete darkness	
Dilution water	EPA soft water	
pH	Not reported	**Doc./Accept. points**

O. tshawytscha	**Viant et al. 2006**	
Parameter	**Value**	**Comment**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported	**Doc./Accept. points**
Feeding	None during exposure	
Purity of test substance	Technical grade	
Concentrations measured?	No	**Doc. points**
Measured is what % of nominal?	Not applicable	
Toxicity values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Not applicable	**Doc. points**
Concentration of carrier (if any) in test solutions	Concentration not reported, methanol	**Accept. points**
Concentration 1 Nom; Meas (μg/L)	1	5 reps, 15/rep
Concentration 2 Nom; Meas (μg/L)	10	5 reps, 15/rep
Concentration 3 Nom; Meas (μg/L)	100	5 reps, 15/rep
Control	Solvent and negative	5 reps, 15/rep
LC_{50} (95% CI) (μg/L)	16.7	Method: maximum likelihood probit

Notes:

Reliability points taken off for:
Documentation: Analytical method (4), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Hypothesis tests (8). Total: 100-28=72

Acceptability: Measured concentrations within 20% nominal (4), Carrier solvent (4), Organisms randomized (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Number of concentrations (3), Random design (2), Dilution factor (2), Hypothesis tests (3). Total: 100-32=68

Reliability score: mean(72, 68)=70

Water Toxicity Data Summary

Oncorhynchus tshawytscha

Wheelock CE, Eder KJ, Werner I, Huang H, Jones PD, Brammell BF, Elskus AA, Hammock BD (2005) Individual variability in esterase activity and CYP1A levels in Chinook salmon (*Oncorhynchus tshawytscha*) exposed to esfenvalerate and chlorpyrifos. Aquatic Toxicol 74:172-192

Relevance	Reliability
Score: 75	Score: 72.5
Rating: L	Rating: L

Relevance points taken off for: Standard method (10), Toxicity value not calculated (15)

O. tshawytscha	**Wheelock et al. 2005**	
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum/subphylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	*tshawytscha*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	5-6 mon old	
Source of organisms	Nimbus Salmon and Steelhead Hatchery (Rancho Cordova, CA)	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	
Test vessels randomized?	Not reported	
Test duration	96 h	
Effect 1	Survival	
Control response 1	100%	
Temperature	14.8 $\pm$ 0.5 ^{o}C	

O. tshawytscha	**Wheelock et al. 2005**	
Parameter	**Value**	**Comment**
Test type	Static renewal	Renewed every 24 h
Photoperiod/light intensity	16 h light: 8 h dark	
Dilution water	EPA reconstituted water	
pH	8.4	
Hardness	Not reported	
Alkalinity	Not reported	
Conductivity	680 µS/cm	
Dissolved Oxygen	9.1 mg/L	
Feeding	None during test	
Purity of test substance	98%	
Concentrations measured?	Yes	
Measured is what % of nominal?	~80-120% (exact numbers not reported)	
Toxicity values calculated based on nominal or measured concentrations?	Not applicable	
Chemical method documented?	Yes, GC/MS	
Concentration of carrier (if any) in test solutions	0.005% methanol	
Concentration 1 Nom (µg/L)	0.01	1 rep, 10/rep
Concentration 2 Nom (µg/L)	0.1	1 rep, 10/rep
Concentration 3 Nom (µg/L)	1	1 rep, 10/rep
Control	Solvent and negative	1 rep, 10/rep
LC_{50} (95% CI) (µg/L)	Not reported	Method: not applicable

Notes:

Reliability points taken off for:
Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Statistics method (5), Hypothesis tests (8), Point estimates (8). Total: 100-28=72

Acceptability: Standard method (5), Organisms randomized (1), Hardness (2), Alkalinity (2), Number of concentrations (3), Random design (2), Adequate replication (2), Dilution factor (2), Statistical method (2), Hypothesis tests (3), Point estimates (3). Total: 100-27=73

Reliability score: mean(72, 73)=72.5

Water Toxicity Data Summary

Pimephales promelas

Belden JB, Lydy MJ (2006) Joint toxicity of chlorpyrifos and esfenvalerate to fathead minnows and midge larvae. Environ Toxicol Chem 25:623-629.

Relevance	Reliability
Score: 85	Score: 62
Rating: L	Rating: L

Relevance points taken off for: Control not described and response not reported (15 - mobility)

P. promelas	**Belden & Lydy 2006**	
Parameter	**Value**	**Comment**
Test method cited	USEPA 1994	
Phylum/subphylum	Chordata	
Class	Actinoptetygii	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Pimephales*	
Species	*promelas*	
Native to	North America	
Age/size at start of test/growth phase	Juveniles, <24 h	
Source of organisms	Aquaculture facility	Logan Hollow, Murphysboro, IL
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Not reported	**Accept. points**
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	**Accept. points**
Effect 1	Mobility	Ability to swim away after gently probing while maintaining an upright position
Control response 1	Mobility: not reported	

P. promelas	**Belden & Lydy 2006**	
Parameter	**Value**	**Comment**
	Mortality: <10%	
Temperature	21 $\pm$ 2 ^{o}C	**Accept. points**
Test type	Static renewal	At 24 h
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	EPA Moderately hard water	
pH	7.8-8.3	
Hardness	Meas., not reported. Met EPA specifications	**Doc. points**
Alkalinity	Meas., not reported. Met EPA specifications	**Doc. points**
Conductivity	Meas., not reported. Met EPA specifications	**Doc. points**
Dissolved Oxygen	>70% saturation	
Feeding	Fed twice daily frozen brine shrimp	**Accept. points**
Purity of test substance	98%	
Concentrations measured?	No	
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Not applicable	**Doc. points**
Concentration of carrier (if any) in test solutions	Not reported	**Accept. points**
Concentration 1 Nom /meas (µg/L)	5 concentrations, conc. Not reported **Doc. points**	4 reps, 10/rep
Concentration 2 Nom /meas (µg/L)	"	
Concentration 3 Nom /meas (µg/L)	"	
Concentration 4 Nom /meas (µg/L)	"	
Concentration 5 Nom /meas (µg/L)	"	
Control	Not described	**Doc./Accept. points**
EC_{50} (95% CI) (µg/L)	0.44 (0.41-0.48)	Method: log-probit
EC_{10} (95% CI) (µg/L)	0.31 (0.27-0.34)	Method: log-probit

Notes:

Reliability points taken off for:
Documentation: Control description (8), Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Conductivity (2), Photoperiod (3), Hypothesis tests (8). Total: 100-35=65

Acceptability: Exposure duration (2), Control description (6), Control response (9), Measured concentration within 20% nominal (4), Carrier solvent (4), Feeding (3), Acclimation (1), Temperature variation (3), Photoperiod (2), Random design (2), Dilution factor (2), Hypothesis tests (3). Total: 100- 41=59

Reliability score: mean(65, 59)=62

Water Toxicity Data Summary

Rana spp.

Materna EJ, Rabeni CF, LaPoint TW (1995) Effects of the synthetic pyrethroid insecticide, esfenvalerate, on larval leopard frogs (*Rana* spp.). Environ Toxicol Chem 14:613-622

Relevance	Reliability
Score: 90	Score: 70.5
Rating: R	Rating: L

Relevance points taken off for: Standard method (10)

***Rana* spp.**	**Materna et al. 1995**	
Parameter	**Value**	**Comment**
Test method cited	None cited	
Phylum/subphylum	Chordata	
Class	Amphibia	
Order	Anura	
Family	Ranidae	
Genus	*Rana*	
Species	*pipiens* complex (*pipiens*, *sphenocephala*, *blairi*)	3 spp.
Family native to North America?	Yes	
Age/size at start of test/growth phase	Tadpoles, 6-8 d post-hatch	
Source of organisms	Multiple: commercial supply (Carolina Biological Supply Co, Burlington, NC), wild collected (shallow pond near Ashland, MS)	
Have organisms been exposed to contaminants?	Possibly (wild collected)	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	
Test duration	96 h	
Effect 1	Survival	

***Rana* spp.**	**Materna et al. 1995**	
Parameter	**Value**	**Comment**
Control response 1	100%	
Effect 2	Convulsions or convulsive response – spasmodic twitching, and twisting of the body and tail	
Control response 2	0% tadpoles convulsing	
Temperature	20 ^{o}C 18, 22 ^{o}C	
Test type	Static	
Photoperiod/light intensity	Not reported	
Dilution water	Well water	
pH	6.3-9.2	
Hardness	Not reported	
Alkalinity	106-230 mg/L $CaCO_3$	
Conductivity	41-739 umhos/cm	
Dissolved Oxygen	Not reported	
Feeding	None before or during test	
Purity of test substance	85%	
Concentrations measured?	Yes	
Measured is what % of nominal?	45-48%	
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Chemical method documented?	Yes, GC-ECD	
Concentration of carrier (if any) in test solutions	0.5 mL/L acetone	
Concentration 1 Nom (µg/L)	0.8	2 reps, 20/rep
Concentration 2 Nom (µg/L)	1.3	2 reps, 20/rep
Concentration 3 Nom; Meas (µg/L)	2.2; 1.74	2 reps, 20/rep
Concentration 4 Nom (µg/L)	3.6	2 reps, 20/rep
Concentration 5 Nom; Meas (µg/L)	6.0; 5.15	2 reps, 20/rep
Concentration 6 Nom (µg/L)	10.0	2 reps, 20/rep
Control	Solvent and negative	2 reps, 20/rep
LC_{50} (95% CI) (µg/L)	22 ^{o}C: 7.29	Method: not reported
EC_{50} (95% CI) (µg/L)	Convulsive behavior 18 ^{o}C: 3.40	Method: not reported

***Rana* spp.**	**Materna et al. 1995**	
Parameter	**Value**	**Comment**
	20 ^{o}C: 4.85 22 ^{o}C: 6.14	

Notes:

Reliability points taken off for:
Documentation: Measured concentrations (3), Hardness (2), Dissolved oxygen (4), Photoperiod (3), Statistics method (5), Hypothesis tests (8). Total: 100-25=75

Acceptability: Standard method (5), Measured concentrations within 20% nominal (4), No prior contamination (4), Exposure type (2), Hardness (2), Dissolved oxygen (6), Photoperiod (2), Random design (2), Adequate replication (2), Statistical method (2), Hypothesis tests (3). Total: 100-34=66

Reliability score: mean(75, 66)=70.5

Appendix A3 – Aqueous Toxicity Studies rated N, LN, RN

Water Toxicity Data Summary

Brachycentrus americanus

Palmquist KR, Jepson PC, Jenkins JJ (2008a) Impact of aquatic insect life stage and emergence strategy on sensitivity to esfenvalerate exposure. Environ Toxicol Chem 27:1728-1734

Relevance	Reliability
Score: 82.5	Score: 59.5
Rating: L	Rating: N

Relevance points taken off for: Standard method (10), Control description (7.5)

B. americanus	**Palmquist et al. 2008a**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Insecta	
Order	Trichoptera	
Family	Brachycentridae	
Genus	*Brachycentrus*	
Species	*americanus*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Pupae	
Source of organisms	Field collected from a pristine site	Metolious River, Camp Sherman, OR
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	
Effect 1	Emergence (post-expsoure)	
Control response 1	97%	
Effect 2	Egg weight as a percent of total female body weight	
Control response 2	31%	
Temperature	$11 \pm 2\ ^{o}C$	

B. americanus	**Palmquist et al. 2008a**	
Parameter	**Value**	**Comment**
Test type	Static	
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	Well water	
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported, but aerated during test	**Doc./Accept. points**
Feeding	None during exposure	
Purity of test substance	Analytical grade (purchased from ChemService)	
Concentrations measured?	Yes	
Measured is what % of nominal?	66-104%	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Yes, GC/MS	
Concentration of carrier (if any) in test solutions	Acetone, conc. not reported	**Accept. points**
Concentration 1 Nom; Meas (μg/L)	0.025	Test 1:4 reps, 10/rep Test 2: 3 reps, 10/rep
Concentration 2 Nom; Meas (μg/L)	0.05	4 reps, 10/rep Test 2: 3 reps, 10/rep
Concentration 3 Nom; Meas (μg/L)	0.1	Test 1:4 reps, 10/rep Test 2: 3 reps, 10/rep
Concentration 4 Nom; Meas (μg/L)	0.2	Test 1:3 reps, 10/rep

B. americanus	**Palmquist et al. 2008a**	
Parameter	**Value**	**Comment**
		Test 2: 3 reps, 10/rep
Control	Not described, likely negative control	4 reps, 10/rep **Doc./Accept. points**
NOEC	Emergence: 0.05 Percentage egg weight in females: 0.025	Method: ANOVA p: 0.05 MSD: not reported **Doc./Accept. points**
LOEC	Emergence: 0.1 Percentage egg weight in females: 0.05	
MATC (GeoMean NOEC,LOEC)	Emergence: 0.07 Percentage egg weight in females: 0.04	
% control at NOEC	Emergence: 85/97*100=88% Percentage egg weight in females: 26/31*100=84%	
% control at LOEC	Emergence: 70/97*100=72% Percentage egg weight in females: 22/31*100=71%	

Notes:

Reliability points taken off for:
Documentation: Control type (8), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Photoperiod (3), Minimum significant difference (2), Point estimates (8). Total: 100-37=63

Acceptability: Standard method (5), Appropriate control (6), Measured concentrations within 20% nominal (4), Carrier solvent (4), Organisms randomized (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Photoperiod (2), Number of concentrations (3), Random design (2), Minimum significant difference (1), Point estimates (3). Total: 100-44=56

Reliability score: mean(63, 56)=59.5

Water Toxicity Data Summary

Chironomus riparius

Forbes VE, Cold A (2005) Effects of the pyrethroid esfenvalerate on life-cycle traits and population dynamics of *Chironomus riparius*--importance of exposure scenario. Environ Toxicol. Chem. 24(1):78-86.

Relevance	Reliability
Score: 67.5	Score: not applicable
Rating: N	Rating: not applicable

Reasons if less than 100 pts for relevance:
Standard method (10), chemical purity (15), control described (7.5)

Water Toxicity Data Summary

Cinygmula reticulata

Palmquist KR, Jepson PC, Jenkins JJ (2008a) Impact of aquatic insect life stage and emergence strategy on sensitivity to esfenvalerate exposure. Environ Toxicol Chem 27:1728-1734

Relevance	Reliability
Score: 82.5	Score: 59
Rating: L	Rating: N

Relevance points taken off for: Standard method (10), Control description (7.5)

C. reticulata	**Palmquist et al. 2008a**	
Parameter	**Value**	**Comment**
Test method cited	None cited	**Accept. points**
Phylum/subphylum	Arthropoda	
Class	Insecta	
Order	Ephemeroptera	
Family	Heptageniidae	
Genus	*Cinygmula*	
Species	*reticulata*	
Family native to North America?	Yes	
Age/size at start of test/growth phase	Experiment 1: Final-instar nymphs Experiment 2: Large late-instar nymphs (at least 20 d from emergence)	
Source of organisms	Field collected from a pristine site	Metolious River, Camp Sherman, OR
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	48 h	
Effect 1	Emergence mortality of final-instars	Death during failed attempt to emerge
Control response 1	3%	

C. reticulata	**Palmquist et al. 2008a**	
Parameter	**Value**	**Comment**
Effect 2	Successful emergence of final instars	
Control response 2	94%	
Effect 3	Post-exposure survival of late-instars	
Control response 3	95%	
Temperature	11 $\pm$ 2 ^{o}C	
Test type	Static	
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	Well water	
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported, but aerated during test	**Doc./Accept. points**
Feeding	None during exposure	
Purity of test substance	Analytical grade (purchased from ChemService)	
Concentrations measured?	Yes	
Measured is what % of nominal?	66-104%	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	Yes, GC/MS	
Concentration of carrier (if any) in test solutions	Acetone, conc. not reported	**Accept. points**
Concentration 1 Nom; Meas (μg/L)	0.005	Exp 1: 3 tests, 4 reps, 10/rep Exp 2: 4 reps, 10/rep
Concentration 2 Nom; Meas (μg/L)	0.01	Exp 1: 3 tests, 4 reps, 10/rep

C. reticulata	**Palmquist et al. 2008a**	
Parameter	**Value**	**Comment**
		Exp 2: 4 reps, 10/rep
Concentration 3 Nom; Meas (μg/L)	0.15	Exp 1: 3 tests, 4 reps, 10/rep Exp 2: 4 reps, 10/rep
Control	Not described, likely negative control	Exp 1: 3 tests, 4 reps, 10/rep Exp 2: 4 reps, 10/rep **Doc./Accept. points**
NOEC	Experiment 1 (final instars) Emergence: < 0.005 Successful emergence: < 0.005 Experiment 2 (late instars) Post-exposure mortality: 0.01	Method: ANOVA p: 0.05 MSD: not reported **Doc./Accept. points**
LOEC	Experiment 1 (final instars) Emergence: 0.005 Successful emergence: 0.005 Experiment 2 (late instars) Post-exposure mortality: 0.025	
MATC (GeoMean NOEC,LOEC)	Experiment 2 (late instars) Post-exposure mortality: 0.016	
% control at NOEC	Experiment 2 (late instars) Post-exposure mortality: 88/95*100=93%	
% control at LOEC	Experiment 2 (late instars) Post-exposure mortality: not reported	**Accept. points**

Notes:

Reliability points taken off for:

Documentation: Control type (8), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Photoperiod (3), Minimum significant difference (2), Point estimates (8). Total: 100-37=63

Acceptability: Standard method (5), Appropriate control (6), Measured concentrations within 20% nominal (4), Carrier solvent (4), Organisms randomized (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Photoperiod (2), Number of concentrations (3), Random design (2), Minimum significant difference (1), % control at LOEC (1), Point estimates (3). Total: 100-45=55

Reliability score: mean(63, 55)=59

Water Toxicity Data Summary

Cyprinus carpio

Ohkawa, H, Kikuchi, R, Miyamoto, J. (1980) Bioaccumulation and Biodegradation of the (S)-Acid Isomer of Fenvalerate (Sumicidin) in an Aquatic Model Ecosystem. J. Pesticide Sci. 5, 11-22.

Relevance	Reliability
Score: 45	Score: not applicable
Rating: N	Rating: not applicable

Reasons if less than 100 pts for relevance:
Standard method (10), endpoint linked to survival/growth (15), chemical purity (15), Toxicity Values (15)

Water Toxicity Data Summary

Daphnia magna

Beketov MA (2004) Comparative sensitivity to the insecticides deltamethrin and Esfenvalerate of some aquatic insect larvae Ephemeroptera and Odonata) and *Daphnia magna.* Russian J Ecology 35:200-204

Relevance	Reliability
Score: 85	Score: 49.5
Rating: L	Rating: N

Reasons if less than 100 pts for relevance: Chemical purity (15)

D. magna	**Beketov 2004**	
Parameter	**Value**	**Comment**
Test method cited	Russian standard method for daphnid	
Phylum/subphylum	Arthropoda	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Native to	North America	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	In-house Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Not reported	**Accept. points**
Test vessels randomized?	Not reported	**Accept. points**
Test duration	96 h	
Data for multiple times?	Can be estimated from Fig. 1b	
Effect 1	Survival	
Control response 1	>90%	
Temperature	20±3 ^{o}C	**Accept. points**

D. magna	**Beketov 2004**	
Parameter	**Value**	**Comment**
Test type	Not reported	**Doc./Accept. points**
Photoperiod/light intensity	Not reported	**Doc./Accept. points**
Dilution water	Culture water (not described)	**Doc./Accept. points**
pH	Not reported	**Doc./Accept. points**
Hardness	Not reported	**Doc./Accept. points**
Alkalinity	Not reported	**Doc./Accept. points**
Conductivity	Not reported	**Doc./Accept. points**
Dissolved Oxygen	Not reported	**Doc./Accept. points**
Feeding	None during test	
Purity of test substance	50 g/L emulsion	Sumi-Alfa **Accept. points**
Concentrations measured?	Not reported	
Measured is what % of nominal?	Not applicable	**Accept. points**
Toxicity Values calculated based on nominal or measured concentrations?	Nominal	
Chemical method documented?	No	**Doc. points**
Concentration of carrier (if any) in test solutions	Not reported	**Accept. points**
Concentration 1 Nom; Meas (μg/L)	Not reported **Doc. points** Dilution factor **Accept. points** # of conc. **Accept. points**	3 reps # per rep not reported **Accept points**
Concentration 2 Nom; Meas (μg/L)	"	
Concentration 3 Nom; Meas (μg/L)	"	
Concentration 4 Nom; Meas (μg/L)	"	
Concentration 5 Nom; Meas (μg/L)	"	

D. magna	**Beketov 2004**	
Parameter	**Value**	**Comment**
Control	Negative	**Accept. points**
LC_{50} (95% CI) (µg/L)	0.029 (0.017-0.050)	Method: trimmed Spearman-Karber

Notes:

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Exposure type (5), Dilution water (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3), Photoperiod (3), Hypothesis tests (8). Total: 100-42=58

Acceptability: Appropriate control (6), Chemical Purity (10), Measured within 20% of nominal (4), Carrier solvent (4), Organisms randomized (1), Organisms per rep (2), Exposure type (2), Dilution water (2), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Temperature variation (3), Conductivity (1), pH (2), Photoperiod (2), Number of concentrations (3), Random design (2), Dilution factor (2), Hypothesis tests (8). Total: 100-59=41.

Reliability score: mean(58, 41)=49.5

Water Toxicity Data Summary

Daphnia spp.

Knillmann S, Stampfli NC, Noskov YA, Beketov MA, Liess M (2012) Interspecific competition delays recovery of *Daphnia* spp. populations from pesticides stress. Ecotoxicol 21:1039-1049

Relevance	Reliability
Score: 67.5	Score: n/a
Rating: N	Rating: n/a

Relevance points taken off for: Standard method (10), Chemical purity (15), Control response not reported (7.5)

Water Toxicity Data Summary

Lepomis macrochirus

Webber, EC, Deutsch, WG, Bayne, DR, Seesock, WC (1992) Ecosystem-level testing of a synthetic pyrethroid insecticide in aquatic mesocosms. Environ Toxicol Chem 11(1):87-105.

Relevance	Reliability
Score: 60	Score: not applicable
Rating: N	Rating: not applicable

Reasons if less than 100 pts for relevance:
Standard method (10), chemical purity (15), toxicity values (15)

Water Toxicity Data Summary

Multiple invertebrates

Lozano, SJ, O'Hallora, SL, and Sargen, KW (1992) Effects of esfenvalerate on aquatic organisms in littoral enclosures. Environ Toxicol Chem 11:35-47.

Relevance	Reliability
Score: 67.5	Score: n/a
Rating: N	Rating: n/a

Reasons if less than 100 pts for relevance:
Acceptable Standard (15), Chemical purity (15), control response (7.5)

Water Toxicity Data Summary

Pimephales promelas

Heinis, LJ, Knuth, ML (1992) The mixing, distribution and persistence of esfenvalerate within littoral enclosures. Environ Toxicol Chem 11(1):11-25.

Relevance	Reliability
Score: 60	Score: not applicable
Rating: N	Rating: not applicable

Reasons if less than 100 pts for relevance:
Standard method (10), endpoint linked to survival (15), toxicity values (15)

Water Toxicity Data Summary

Rana temporaria

Johansson M, Piha H, Kylin H, Merila J (2006) Toxicity of six pesticides to common frog (*Rana temporaria*) tadpoles. Environ Toxicol Chem 25:3164-3170.

Relevance	Reliability
Score: 60	Score: n/a
Rating: N	Rating: n/a

Relevance points taken off for: Standard method (10), Chemical purity not stated (15), Toxicity values not calculable (15)

Appendix B – Sediment Toxicity Data Summaries

Appendix B1 – Sediment Toxicity Studies rated RR

Sediment Toxicity Data Summary

Chironomus dilutus

Picard CR (2010a) 10-day toxicity test exposing midges (*Chironomus dilutus*) to esfenvalerate applied to formulated sediment under static renewal conditions following OPPTS Draft Guideline 850.1735. Performed by Springborn Smithers Laboratories, Wareham, MA, Study No. 13656.6145; submitted to Pyrethroid Working Group, Washington, DC. DPR study ID: 254437

Relevance
Score: 100
Rating: R

Reliability
Score: 92
Rating: R

C. dilutus	**Picard 2010a**	
Parameter	**Value**	**Comment**
Test method cited	EPA OPPTS Draft Guideline 850.1735	Springborn Smithers Lab protocol no.:102809/OPPTS/10-day midge
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Chironomidae	
Genus	*Chironomus*	
Species	*dilutus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	11 d old, third instar larvae	
Source of organisms	Springborn Smithers lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	10 day	
Effect 1	Survival	
Control response 1	96% negative control; 96% solvent control survival	Control data pooled
Effect 2	Growth	Ash free dry weight
Control response 2	1.02 mg in negative control and 1.27 mg solvent control	Control data pooled
Temperature	23±1°C	

C. dilutus	**Picard 2010a**	
Parameter	**Value**	**Comment**
Test type	Static renewal	Renew 50 mL water 7x/day
Photoperiod/light intensity	16 h light 510-680 lux; 8 h dark	
Overlying water	Well water	
pH	6.5-7.4	
Hardness	68-76 mg/L as $CaCO_3$	
Alkalinity	22-28 mg/L as $CaCO_3$	
Conductivity	380-420 µmhos/cm	
Dissolved Oxygen	3.8-8.0 mg/L (44-93% saturation)	**Accept. points**
Chemical analysis?/Method	Yes	LCS
Sediment source	Formulated according to OECD Guideline 218	
Organic carbon	2.2%	
Particle size distribution (sand, silt, clay)	75%, 6%, 19%	
pH	7.2	
Percent solids	70.67%	
Sediment spike procedure	Jar rolling technique. 10 mL acetone added to 0.05 kg sand, solvent evaporated, then added to 2.5 kg wet sediment (1.2168 kg dry wt)	Roll twice/week for 2 h @ RT during equilibration
Sediment spike equilibration time	14 days at 2-8°C	**Accept. points**
Sediment to Solution ratio	100ml(4cm):175 mL	164 g wet or 116g dry wt
Sediment extraction/analysis methods	Solvent extraction, GC/MS	
Interstitial water monitored?	Yes	
Interstitial water isolation method	Centrifugation at 1200g for 15 to 30 min.	Entire sample
Interstitial water extraction/analysis method	SPME conducted by external lab	Date not available
pH	6.9-7.2	
TOC	160-280 mg C/L	
DOC	130-250 mg C/L	
Feeding	Flakes fish food suspension once daily	1.5 mL of 4.0 mg/mL per vessel
Purity of test substance	99.6%	
Measured is what % of nominal?	88-100%	
Toxicity values calculated based on	Measured	

C. dilutus	**Picard 2010a**	
Parameter	**Value**	**Comment**
nominal or measured concentrations?		
Concentration of carrier (if any) in test solutions	0	
Concentration 1 Nom/Meas (µg/kg)	63/ 58	8 reps, 10 per rep
Concentration 2 Nom/Meas (µg/kg)	130/ 130	8 reps, 10 per rep
Concentration 3 Nom/Meas (µg/kg)	250/220	8 reps, 10 per rep
Concentration 4 Nom/Meas (µg/kg)	500/ 480	8 reps, 10 per rep.
Concentration 5 Nom/Meas (µg/kg)	1000/ 1000	8 reps, 10 per rep
Concentration 6 Nom/Meas (µg/kg)	2000/ 1800	8 reps, 10 per rep
Control	Solvent and negative	8 reps, 10 per rep
LC_{50} (95%CI)	Dry-weight 510 (450–570) µg/kg OC-normal 23.2 (20.5-25.9) µg/g OC	Method: log-log analysis (TOXSTAT)
EC_{50} (95% CI) Growth	Dry-weight 210 (190-250) µg/kg OC-normal 9.5 (8.6-11.4) µg/g OC	Method: linear interpolation (TOXSTAT)
NOEC (µg/kg)	Dry-weight Survival: 130 µg/kg Growth: <58 µg/kg OC-normal Survival: 5.9 µg/g OC Growth: <2.6 µg/g OC	Method: Bonferroni's t-test p: 0.05 MSD: no reported **Doc./Accept. points**
LOEC (µg/kg)	Dry-weight Survival: 220 µg/kg Growth: 58 µg/kg OC-normal Survival: 10 µg/g OC Growth: 2.6 µg/g OC	Method: same as above
MATC (GeoMean NOEC, LOEC) (µg/kg)	Dry-weight Survival: 169 µg/kg Growth: not calculable OC-normal Survival: 7.68 µg/g OC	
% of control at NOEC	Survival: 93/96*100=97%	
% of control at LOEC	Survival: 74/96*100=77% Growth: 0.90/1.15*100=78%	

Reliability points taken off for:
Documentation (Table 9): Minimum significant difference (2). Total: 100-2=98

Acceptability (Table 10): Spike equilibration time (6), Dissolved Oxygen >60% (5), Random design (2), Minimum significant difference (1). Total: 100-14=86

Reliability score: Mean (98, 86)=92

Sediment Toxicity Data Summary

Chironomus dilutus

Putt AE (2005a) Esfenvalerate – Toxicity to midge (*Chironomus tentans*) during a 10-day sediment exposure. Performed by Springborn Smithers Laboratories, Wareham, MA, Study ID: 13656.6119; submitted to Pyrethroid Working Group, Washington, DC. DPR ID: 238262.

Relevance
Score: 100
Rating: R

Reliability
Score: 93
Rating: R

C. dilutus	**Putt 2005a**	
Parameter	**Value**	**Comment**
Test method cited	Springborn Smithers Lab protocol no.:051704/EPA/10-day midge esfenvalerate	Following EPA test method
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Chironomidae	
Genus	*Chironomus*	
Species	*dilutus*	formerly *tentans*
Family in North America?	Yes	
Age/size at start of test/growth phase	8 d old, second instar larvae	Head capsule 0.25-0.47 mm confirms life stage
Source of organisms	Springborn Smithers lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Not stated	**Accept. points**
Test duration	10 day	
Effect 1	Survival	
Control response 1	91% negative control; 89% solvent control survival	Control data pooled
Effect 2	Growth	Ash free dry weight
Control response 2	2.26 mg in negative control and 2.35 mg solvent control	Control data pooled
Temperature	23±1°C	
Test type	Static renewal	Renew 50 mL water 12x/day
Photoperiod/light intensity	16 h light:8 h dark; 435-660	

C. dilutus	**Putt 2005a**	
Parameter	**Value**	**Comment**
	lux	
Overlying water	Well water	
pH	6.9-7.1	
Hardness	44-56 mg/L as $CaCO_3$	
Alkalinity	26-36 mg/L as $CaCO_3$	
Conductivity	230-260 µmhos/cm	
Dissolved Oxygen	2.0 – 7.3 mg/L during test (23-82% saturation)	**Accept. points**
Chemical analysis?/Method	Yes, LSC	
Sediment source	Natural; Glen Charlie Pond, Wareham, MA	
Organic carbon	5.5%	
Particle size distribution (sand, silt, clay)	83%, 12%, 5.5%	
pH	4.9	
Sediment spike procedure	Jar rolling technique	9 mL acetone added to 0.05 kg sand, evaporate, add to 2 kg wet sediment (1.2168 kg dry wt)
Sediment spike equilibration time	31 days at 4°C	Roll once/week for 2 h @ RT during equilibration
Sediment to Solution ratio	100ml(4cm):175 mL	122 g wet t or 71 g dry wt
Sediment extraction/analysis method	LSC	
Interstitial water monitored?	Yes	
Interstitial water isolation method	Centrifuge 30 min @ 10,000*g*	Entire sample
Interstitial water extraction/analysis method	LSC (Liquid scintillation counting)	2 mL interstitial water + 15 mL cocktail; concentration in Table 6 in notes
DOC (mg/L)	6.7-8.4 @ d0; 17-39 @ d10	
Feeding	Flakes fish food suspension once daily	1.5 mL of 4.0 mg/mL per vessel
Purity of test substance	95.8% ^{14}C-esfenvalerate after purification from 66.5% as received; specific activity 49.93 µCi/mg using HPLC-radiochemical detection	Technical (99.7%) used for range finding

C. dilutus	**Putt 2005a**	
Parameter	**Value**	**Comment**
	(RAM)	
Measured is what % of nominal?	130-160% based on mean recovery of day 0 and day 10	**Accept. points**
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Concentration of carrier (if any) in test solutions	0	9 mL acetone added to 0.05 kg sand, evaporate, add to 2 kg wet sediment (1.2168 kg dry wt)
Concentration 1 Nom/Meas (µg/kg)	Sediment dry weight 45/ 70 µg/kg Interstitial water (meas only) Mean of t_0 and t_{10}: non-detect (<0.22 µg/L)	8 reps, 10 midges/rep
Concentration 2 Nom/Meas (µg/kg)	90/ 140 Interstitial water (meas only) Mean of t_0 and t_{10}: non-detect (<0.22 µg/L)	8 reps, 10 midges/rep
Concentration 3 Nom/Meas (µg/kg)	180/250 Interstitial water (meas only) t_{10}: 0.27 µg/L	8 reps, 10 midges/rep
Concentration 4 Nom/Meas (µg/kg)	350/ 470 Interstitial water (meas only) Mean of t_0 and t_{10}: 0.48 µg/L	8 reps, 10 midges/rep
Concentration 5 Nom/Meas (µg/kg)	700/ 970 Interstitial water (meas only) Mean of t_0 and t_{10}: 0.88 µg/L	8 reps, 10 midges/rep
Concentration 6 Nom/Meas (µg/kg)	1400/ 1800 Interstitial water (meas only) Mean of t_0 and t_{10}: 1.5 µg/L	8 reps, 10 midges/rep
Control	Solvent and negative	8 reps, 10 midges/rep
LC_{50} (95%CI)	Dry weight 1100 (820 – 1300) µg/kg OC-normal 20 (14.9-23.6) µg/g OC	Method: Inhibition concentration method (TOXSTAT 3.5)
EC_{50} (95% CI)	Dry weight 450 (350 – 570) µg/kg OC-normal 8.18 (6.36-10.4) µg/g OC	Method: Inhibition concentration method (TOXSTAT 3.5)
NOEC	Dry weight Survival: 250 µg/kg	Method: Williams test

C. dilutus	**Putt 2005a**	
Parameter	**Value**	**Comment**
	Growth: 140 µg/kg OC-normal Survival: 4.55 µg/g OC Growth: 2.55 µg/g OC	p: 0.05 (TOXSTAT 3.5) MSD: not reported **Doc./Accept. points**
LOEC	Dry weight Survival: 470 µg/kg Growth: 250 µg/kg OC-normal Survival: 8.55 µg/g OC Growth: 4.55 µg/g OC	Same as above
MATC (GeoMean NOEC,LOEC)	Dry weight Survival: 343 µg/kg Growth: 187 µg/kg OC-normal Survival: 6.24 µg/g OC Growth: 3.4 µg/g OC	
% of control at NOEC	Survival: 91/90*100=101% Growth: 2.24/2.31*100=97%	
% of control at LOEC	Survival: 74/90*100=82% Growth: 1.47/2.31*100=64%	

Notes:

Protocol meets requirements USEPA Test method 100.2 "Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates" (USEPA, 2000) and 40 CFR, Part 158.

Reliability points taken off for:
Documentation (Table 9): Minimum significant difference (2). Total: 100-2=98

Acceptability (Table 10): Measured Concentrations within 20% of nominal (4), Dissolved oxygen >60% saturation (5), Random design (2), Minimum significant difference (1). Total: 100-12=88

Reliability score: Mean (98, 88)=93

Sediment Toxicity Data Summary

Hyalella azteca

Picard CR (2010b) 10-day toxicity test exposing freshwater amphipods (*Hyalella azteca*) to esfenvalerate applied to formulated sediment under static renewal conditions. Performed by Springborn Smithers Laboratories, Wareham, MA, study 13656.6135; submitted to Pyrethroid Working Group, Washington, DC. DPR ID: 254436

Relevance
Score: 100
Rating: R

Reliability
Score: 97.5
Rating: R

H. azteca	**Picard 2010b**	
Parameter	**Value**	**Comment**
Test method cited	Springborn Smithers Lab protocol no.:100808/OPPTS/10-day Hyalella/artificial sed	OPPTS Draft Guideline 850.1735
Phylum	Arthropoda: Crustacea	
Class	Malacostraca	
Order	Amphipoda	
Family	Hyalellidae	
Genus	*Hyalella*	
Species	*azteca*	
Family in North America?	Yes	
Age/size at start of test/growth phase	8 d old	
Source of organisms	Springborn Smithers lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Not reported	**Accept. points**
Test duration	10 day	
Effect 1	Survival	
Control response 1	97% negative control; 97% solvent control survival	Control data pooled
Effect 2	Growth	Ash free dry weight
Control response 2	0.10 mg in negative control and 0.09 mg solvent control	Control data pooled
Temperature	21 to 25°C with continuous measure	
Test type	Static renewal	Renew 50 mL water 7x/day
Photoperiod/light intensity	16 h light 530-740 lux; 8 h	

H. azteca	**Picard 2010b**	
Parameter	**Value**	**Comment**
	dark	
Overlying water	Well water	
pH	7.0-7.4	
Hardness	64-72 mg/L as $CaCO_3$	
Alkalinity	22-26 mg/L as $CaCO_3$	
Conductivity	380-400 µmhos/cm	
Dissolved Oxygen	6.6-8.3 mg/L (>77% sat)	
Chemical analysis?/Method	Yes, LSC	
Sediment source	Formulated according to OECD Guideline 218	
Organic carbon	2.1%	
Particle size distribution (sand, silt, clay)	71%, 7%, 22%	
pH	7.1	
Percent solids	63.79%	
Sediment spike procedure	Jar rolling technique. 10 mL acetone added to 0.05 kg sand, evaporate, add to 2.5 kg wet sediment (1.2168 kg dry wt)	Roll twice/week for 2 h @ RT during equilibration
Sediment spike equilibration time	14 days at 2-8°C	**Accept. points**
Sediment to Solution ratio	100ml(4cm):175 mL	140 g wet or 89.5g dry wt
Sediment extraction/analysis method	GC/MS	
Interstitial water monitored?	Yes	
Interstitial water isolation method	Centrifugation at 1200g for 15 to 30 min.	Entire sample
Interstitial water extraction/analysis method	SPME	Conducted by external lab
DOC	95-160 mg C/L	
Feeding	1.0mL/day yeast, cereal, flake food combo (YCT)	
Purity of test substance	99.6%	
Measured is what % of nominal?	83 to 96%	
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Concentration of carrier (if any) in test solutions	0	
Concentration 1 Nom/Meas (µg/kg)	1.0/0.90	8 reps, 10/rep
Concentration 2 Nom/Meas (µg/kg)	2.0/1.8	8 reps, 10/rep
Concentration 3 Nom/Meas (µg/kg)	4.0/3.7	8 reps, 10/rep

H. azteca	**Picard 2010b**	
Parameter	**Value**	**Comment**
Concentration 4 Nom/Meas (µg/kg)	8.0/6.6	8 reps, 10/rep
Concentration 5 Nom/Meas (µg/kg)	16/15	8 reps, 10/rep
Concentration 6 Nom/Meas (µg/kg)	32/28	8 reps, 10/rep
Control	Solvent and negative	8 reps, 10/rep
LC_{50} (95% CI)	Dry weight 7.8 (7.1-8.7) µg/kg OC-normal 0.37 (0.34-0.41) µg/g OC	Method: probit (TOXSTAT)
EC_{50} (95% CI)	Dry weight 6.0 (5.7-6.4) µg/kg OC-normal 0.29 (0.27-0.30) µg/g OC	Method: linear interpolation (TOXSTAT)
NOEC	Dry weight Survival: 3.7 µg/kg Growth: 3.7 µg/kg OC-normal Survival: 0.18 µg/g OC Growth: 0.18 µg/g OC	Method: Wilcoxon's Rank Sum Test with Bonferroni adjustment (survival), Bonferroni's t-test (growth) p: 0.05 MSD: not reported **Doc./Accept. points**
LOEC	Dry weight Survival: 6.6 µg/kg Growth: >3.7 µg/kg OC-normal Survival: 0.31 µg/g OC Growth: >0.18 µg/g OC	Method: same as above
MATC (GeoMean NOEC,LOEC)	Dry weight Survival: 4.9 µg/kg Growth: not calculable OC-normal Survival: 0.23 µg/g OC	
% of control at NOEC	Survival: 94/99*100=95% Growth: 0.10/0.11*100=91%	
% of control at LOEC	Survival: 58/99*100=59% Growth: not calculable	

Reliability points taken off for:
Documentation (Table 9): Minimum significant difference (2). Total: 100-2=98

Acceptability (Table 10): Random design (2), Minimum significant difference (1). Total: 100-3=97

Reliability score: Mean (98, 97)=97.5

Appendix B2 – Sediment Toxicity Studies rated RL, LR, LL

Sediment Toxicity Data Summary

Hyalella azteca

Amweg EL, Weston DP, Ureda NM (2005) Use and toxicity of pyrethroid pesticides in the Central Valley, California, UAS. Environ Toxicol Chem 24: 966-972.

Relevance	Reliability
Score: 85	Score: 70.5
Rating: L	Rating: L

* Relevance points taken off for: Toxicity values were not based on acceptable bioavailable concentrations (15). They were based on nominal (not measured) concentrations.

H. azteca	**Amweg et al. 2005**	
Parameter	**Value**	**Comment**
Test method cited	EPA 2000	
Phylum	Arthropoda: Crustacea	
Class	Malacostraca	
Order	Amphipoda	
Family	Hyalellidae	
Genus	*Hyalella*	
Species	*azteca*	
Family in North America?	Yes	
Age/size at start of test/growth phase	6-10 d	< 350 um, < 500 um
Source of organisms	Not stated	**Doc. points**
Have organisms been exposed to contaminants?	Not stated	**Accept. points**
Animals acclimated and disease-free?	Not stated	**Accept. Points**
Animals randomized?	Not stated	**Accept. Points**
Test vessels randomized?	Not stated	**Accept. Points**
Test duration	10 d	
Effect 1	Survival	
Control response 1	80%	
Effect 2	Growth	
Control response 2	Negative: 76-85 µg Solvent: 80-92 µg	Estimated from Fig. 2C
Temperature	23°C	**Accept. Points**
Test type	Static-renewal	80% renewal every other day
Photoperiod/light intensity	16 h light:8 h dark	
Overlying water	Moderately hard water	Reconstituted from MQ water

H. azteca	**Amweg et al. 2005**	
Parameter	**Value**	**Comment**
pH	Measured, Not stated	**Doc./ Accept. points**
Hardness mg/L as $CaCO_3$	Measured, Not stated	**Doc./ Accept. points**
Alkalinity mg/L as $CaCO_3$	Measured, Not stated	**Doc./ Accept. points**
Conductivity	Measured, Not stated	**Doc./ Accept. points**
Dissolved Oxygen	Measured, Not stated	**Doc./ Accept. points**
Sediment source	3 Natural sediments: American River (AR) Del Puerto Creek (DPC) Pacheco Creek (PC)	
Organic carbon	AR: 1.4% DPC: 1.1% PC: 6.5%	
Particle size distribution (sand, silt, clay)	% silts & clays AR: 43.1% DPC: 31.7% PC: 21.3%	
Sediment spike procedure	<200 µL acetone /kg , mixed with electric drill	**Accept. points**
Sediment spike equilibration time	11-12 day at 4°C	**Accept. points**
Sediment to Solution ratio	50-75 mL:300 mL water	
Sediment extraction/analysis method	Solvent extraction, cleanup, GC/ECD	
Interstitial water monitored?	No	
Interstitial water extraction method	Not applicable	
Interstitial water chemical extraction method	Not applicable	
Interstitial water chemical analysis method	Not applicable	
DOC	Not applicable	
Feeding	Yeast, cerophyll, trout chow mix	Daily; no amounts
Purity of test substance	Technical (>98% pure)	
Concentrations measured?	Yes	
Measured is what % of nominal?	Esfenvalerate: 89% average	
Toxicity values calculated based on nominal or measured	Nominal	**Relevance points**

H. azteca	**Amweg et al. 2005**	
Parameter	**Value**	**Comment**
concentrations?		
Concentration of carrier (if any) in test solutions	<200 uL acetone/kg wet sediment	**Accept. points**
Concentration 1 Nom (μg/kg)	0.172	3 reps, 10/rep **Accept. points** Meas. conc. NR **Doc. Points**
Concentration 2 Nom (μg/g OC)	0.29	3 reps, 10/rep
Concentration 3 Nom (μg/g OC)	0.50	3 reps, 10/rep
Concentration 4 Nom (μg/g OC)	0.84	3 reps, 10/rep
Concentration 5 Nom (μg/g OC)	1.39	3 reps, 10/rep
Concentration 6 Nom (μg/g OC)	2.32	3 reps, 10/rep
Concentration 7 Nom (μg/g OC)	3.89	3 reps, 10/rep
Concentration 8 Nom (μg/g OC)	6.47	3 reps, 10/rep
Control	Solvent and negative	3 reps, 10/rep
LC_{50} (95% confidence interval)	Dry weight AR: 24.3 (21.3-27.9) μg/kg DPC: 17.9 (15.3-21.2) μg/kg PC: 83.1 (68.3-102.0) μg/kg OC-normal AR: 1.75 (1.53-2.06) μg/g OC DPC: 1.58 (1.34-1.89) μg/g OC PC: 1.27 (1.05-1.57) μg/g OC	Method: trimmed Spearman-Karber
NOEC	Growth: AR: 0.292 μg/g OC DPC: interrupted dose-response PC: 0.292 μg/g OC	Method: one-tailed Bonferroni's t-test p: 0.05 MSD: not reported **Doc./Accept. points**
LOEC	Growth: AR: 0.499 μg/g OC DPC: interrupted dose-response PC: 0.499 μg/g OC	Same as above
MATC (GeoMean NOEC,LOEC)	Growth: AR: 0.382 μg/g OC PC: 0.382 μg/g OC	Calculated
% of control at NOEC	Growth: AR: 56/80*100=70% PC: 59/92*100=64%	Estimated from Fig. 2C with solvent control results **Accept. points**
% of control at LOEC	Growth:	Same as above

H. azteca	**Amweg et al. 2005**	
Parameter	**Value**	**Comment**
	AR: 55/80*100=69% PC: 40/92*100=43%	

Notes:
An erratum was also provided with this study due to a faulty commercial standard requiring correction to the LC_{50} and NOEC values. This report summary includes all corrected LC_{50} values and confidence intervals as well as the corrected NOEC values.

Protocol follows EPA 2000 "Methods for measuring the toxicity and bioaccumulation. 2nd ed. EPA/600/R-99/064.

Reliability points taken off for:

Documentation : Organism source (4), Measured concentrations (10), Overlying water hardness (1), Overlying water alkalinity (1), Overlying water dissolved oxygen (2), Overlying water conductivity (1), Overlying water pH (1), Minimum significant difference (2). Total: 100-22=78

Acceptability : Sediment spike method (4), Spike equilibration time (6), Carrier solvent (4), Organism not contaminated prior (3), Organisms randomly assigned (1), Organisms properly acclimated (1), Overlying water hardness (1), Overlying water alkalinity (1), Overlying water dissolved oxygen (5), Overlying water conductivity (1), Overlying water pH (1), Temperature variation (3), Random design (2), Adequate replication (2), Minimum significant difference (1), NOEC response reasonable (1). Total: 100-37=63

Reliability score: Mean (78, 63)=70.5

Sediment Toxicity Data Summary

Leptocheirus plumulosus

Putt AE (2005b) Esfenvalerate – Toxicity to estuarine amphipods (*Leptocheirus plumulosus*) during a 28-day sediment exposure. Performed by Springborn Smithers Laboratories, Wareham, MA, study ID: 13656.6120; submitted to Pyrethroid Working Group, Washington, DC. DPR ID: 238265. EPA MRID: 46620401.

Relevance	Reliability
Score: 85	Score: 94
Rating: L	Rating: R

*Relevance points deducted for: Saltwater test (15)

L. plumulosus	**Putt 2005b**	
Parameter	**Value**	**Comment**
Test method cited	Springborn Smithers Lab protocol no.:051704/EPA/28-day Leptocheirus	Following EPA test method
Phylum	Arthropoda	
Class	Malacostraca	
Order	Amphipoda	
Family	Aoridae	
Genus	*Leptocheirus*	
Species	*plumulosus*	
Family in North America?	Yes	East coast of NA
Age/size at start of test/growth phase	Neonate/>0.25mm,<0.6mm	
Source of organisms	Springborn Smithers lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	Observed 48 h at 21-22% salinity and 20°C
Animals randomized?	Yes	
Test vessels randomized?	Not stated	**Accept. points**
Test duration	28 day	
Effect 1	Survival	
Control response 1	90% negative control; 94% solvent control survival	Pooled control survival 92%
Effect 2	Growth	Dry weight
Control response 2	1.29 mg in negative control and 1.02 mg solvent control	Controls pooled = 1.16
Temperature	24-26°C	

L. plumulosus	**Putt 2005b**	
Parameter	**Value**	**Comment**
Test type	Static renewal	Renew 400 mL water 3x/week
Photoperiod/light intensity	16 h light:8 h dark; 600-850 lux	
Overlying water	Filtered seawater	
pH	6.9-8.1	
Hardness	Not stated	**Doc. points**
Alkalinity	Not stated	**Doc. points**
Conductivity	19-21% salinity	**Doc. points**
Dissolved Oxygen	5.2 – 7.1 mg/L during test (>60% saturation)	
TOC	<2 mg/L	
Ammonia-N	5.8 – 6.4 mg/L @ day 0 <0.10 – 6.4 mg/L @ day 28	
Chemical analysis?/Method	Yes, LCS	
Sediment source	Natural marine; Little harbor beach, Wareham, MA	
Organic carbon	4.8%	
Particle size distribution (sand, silt, clay)	68%, 20%, 12%	
pH	6.6	
Percent solids	43.42%	
Sediment spike procedure	Jar rolling technique	9 mL acetone added to 0.05 kg sand, evaporate, add to 2 kg wet sediment (0.8684 kg dry wt)
Sediment spike equilibration time	29 days at 4°C	Roll once/week for 2 h @ RT during equilibration
Sediment to Solution ratio	175ml(2.0cm):725 mL	190 g wet t or 82 g dry wt
Sediment extraction/analysis method	LSC	
Interstitial water monitored?	Yes	
Interstitial water isolation method	Centrifuge 30 min @ 10,000*g*	Entire sample
Interstitial water extraction/analysis method	LSC (Liquid scintillation counting)	2 mL interstitial water + 15 mL cocktail; concentration in Table 6 in notes
pH	6.0-7.0 during test	

L. plumulosus	**Putt 2005b**	
Parameter	**Value**	**Comment**
DOC	35.9 – 50.7 @ d0; 8.3-13.3 @ d28	See Table 3 in notes
Ammonia-N	43.4 mg/L; 32-36 @ d 0; 1.8-3.3 @ d 28	
Feeding	Flakes fish food suspension 3X/week following water renewal	0-13d 2mL 10mg/mL; 14-27d 4mL 10mg/mL
Purity of test substance	95.8% ^{14}C-esfenvalerate; specific activity 49.93µCi/mmol using HPLC-radiochemical detection (RAM); purified from 66.5% as received	Technical (99.7%) used for range finding
Measured is what % of nominal?	83%-120% in sediment	
Toxicity values calculated based on nominal or measured concentrations?	Measured	
Concentration of carrier (if any) in test solutions	0	9 mL acetone added to 0.05 kg sand, evaporate, add to 2 kg wet sediment (0. 8684 kg dry wt)
Concentration 1 Nom/Meas (µg/kg)	1.9/2.3	5 reps, 20 amphipod/rep
Concentration 2 Nom/Meas (µg/kg)	5.6/ 5.3	5 reps, 20 amphipod/rep
Concentration 3 Nom/Meas (µg/kg)	17/ 14	5 reps, 20 amphipod/rep
Concentration 4 Nom/Meas (µg/kg)	50/ 42	5 reps, 20 amphipod/rep
Concentration 5 Nom/Meas (µg/kg)	150/130	5 reps, 20 amphipod/rep
Concentration 6 Nom/Meas (µg/kg)	450/400	5 reps, 20 amphipod/rep
Control	Solvent and negative	5 reps, 20 amphipod/rep
LC_{50} (95%CI)	Dry weight 180 (130-230) µg/kg OC-normal 3.75 (2.7-4.8) µg/g OC	Method: Inhibition concentration method (TOXSTAT 3.5)
EC_{50} (95%CI)	Dry weight 200 (140 – 230) µg/kg OC-normal 4.2 (2.9-4.8) µg/g OC	Method: Inhibition concentration method (TOXSTAT 3.5)

L. plumulosus	**Putt 2005b**	
Parameter	**Value**	**Comment**
NOEC (μg/kg)	Dry weight Survival: 42 μg/kg Growth: 42 μg/kg OC-normal Survival: 0.875 μg/g OC Growth: 0.875 μg/g OC	Method: Wilcoxon's rank-sum test (survival), Williams test (growth) p: 0.05 (TOXSTAT 3.5) MSD: not reported **Doc./Accept. points**
LOEC	Dry weight Survival: 130 μg/kg Growth: 130 μg/kg OC-normal Survival: 2.7 μg/g OC Growth: 2.7 μg/g OC	Same as above
MATC (GeoMean NOEC,LOEC)	Dry weight Survival: 74 μg/kg Growth: 74 μg/kg OC-normal Survival: 1.5 μg/g OC Growth: 1.5 μg/g OC	
% of control at NOEC	Survival: 89/92*100=97% Growth: 1.06/1.16*100=91%	
% of control at LOEC	Survival: 59/92*100=64% Growth:0.78/1.16*100=67%	

Notes:

Protocol meets requirements USEPA Methods for assessing the chronic toxicity of marine and estuarine sediment associated contaminants with the amphipod *Leptocheirus plumulosus* (USEPA, 2001) and CFR Part 158.

Radiolabeled esfenvalerate used in toxicity testing.

Reliability points taken off for:
Documentation (Table 9): Overlying water hardness (1), Overlying water alkalinity (1), Overlying water conductivity (1), Minimum significant difference (2). Total: 100-5=95

Acceptability (Table 10): Measured concentrations within 20% of nominal (4), Random design (2), Minimum significant difference (1). Total: 100-7=93

Reliability score: Mean (95, 93)=94

Appendix C – Acute WQC Fit Test

Esfenvalerate all SMAVs	Omit one 1	2	3	4	5	6	7	8
0.073		0.073	0.073	0.073	0.073	0.073	0.073	0.073
0.135	0.135		0.135	0.135	0.135	0.135	0.135	0.135
0.169	0.169	0.169		0.169	0.169	0.169	0.169	0.169
0.21	0.21	0.21	0.21		0.21	0.21	0.21	0.21
0.26	0.26	0.26	0.26	0.26		0.26	0.26	0.26
0.26	0.26	0.26	0.26	0.26	0.26		0.26	0.26
0.46	0.46	0.46	0.46	0.46	0.46	0.46		0.46
2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	

Omitted point, xi:	0.0730	0.1350	0.1690	0.2100	0.2600	0.2600	0.4600	2.1700
median 5th percentile								
log-logistic	0.06039	0.04501	0.04187	0.03967	0.038165	0.03817	0.03693	0.06941
percentile	6.86	22.97	31.26	40.14	49.34	49.34	72.91	99.89
F-i(xi)	0.0686	0.2297	0.3126	0.4014	0.4934	0.4934	0.7291	0.9989
1-F(xi)	0.9314	0.7703	0.6874	0.5986	0.5066	0.5066	0.2709	0.0011
Min of F-i(xi) or 1-F(xi)	0.0686	0.2297	0.3126	0.4014	0.4934	0.4934	0.2709	0.0011
p_i =2(min)	0.1372	0.4594	0.6252	0.8028	0.9868	0.9868	0.5418	0.0022

Fisher test statistic

p_i	$\ln(p_i)$	-2*Sum of ln (pi)	X^2_{2n}
0.1372	-1.9863	20.4244	0.2017
0.4594	-0.7778		
0.6252	-0.4697		
0.8028	-0.2196		
0.9868	-0.0133		
0.9868	-0.0133		
0.5418	-0.6129		
0.0022	-6.1193		

0.2017 is > 0.05 so the distribution fits the esfenvalerate acute data set

if $X^2 < 0.05$	significant lack of fit
if $X^2 > 0.05$	fit (no significant lack of fit)